POTENTIAL FOR OILSEED SUNFLOWERS in the UNITED STATES

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The rising prominence of sunflower oil in world edible oil markets has stimulated increased interest in expanded U.S. production. U.S. acreage devoted to oilseed sunflowers has expanded rapidly, with over 600,000 acres grown in 1972. Production has been concentrated in the southern Cotton Belt States and in the Red River Valley area of Minnesota and North Dakota.

This report examines recent trends in domestic fats and oils markets and the possible place of sunflower oil in these markets. Estimates are developed of the yield per acre and price required of sunflowerseed to make it competitive with established crops in the two areas. Also, estimates are made of the costs and profitability of processing sunflowerseed in southern screw-press mills.

Key Words: Sunflowers; fats and oils; oilseeds; oilmeal; vegetable oils; market potential; production economics; processing.

PREFACE

This study was initiated in response to questions by farmers, industry personnel, research administrators, and scientists regarding the economic potential of oilseed sunflowers in the Cotton Belt States.

The authors are indebted to many individuals and firms for information and assistance in carrying out the study. Special thanks are extended to C. H. Harry Neufeld, Director, L. L. McKinney, Assistant Director, and James A. Robertson, Head, Lipids Investigations, Richard B. Russell Agricultural Research Center, Agricultural Research Service, Athens, Ga.; to Dalton Gandy of the National Cottonseed Products Association, Memphis, Tenn.; and to Martin Reed of the French Oil Mill Machinery, Co., Piqua, Ohio.

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CONTENTS

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TEXT TABLES

Dewaxed, refined sunflowerseed oil results in a salad oil with excellent stability, a high nutritional value, and a delicate flavor. Even when off-flavor develops, sunflower oil has a mild, nut-like but still pleasant flavor. Sunflower oil is much esteemed as a salad and cooking oil in Europe and Japan and could find such use in the U.S. market.

Sunflowerseed oil could be used in domestic margarine production. The sunflower's name and attractive flower, and especially the relatively high proportion of polyunsaturated fatty acids in the oil, would contribute to successful market promotion. When sunflower oil is hardened for margarine production, a definite grainy texture may develop. However, various methods are available to overcome this problem, and a premium-grade margarine can be produced that has good flavor, stability, and nutritional benefits.

Shortening prepared from sunflowerseed oil has a good flavor and stability and performs in baking at least equal to shortening produced from soybean oil. For frying, sunflower shortening is superior to soybean oil with respect to polymer buildup and flavor retention. In some instances, it results in lower oil retention in the fried pieces. Thus, sunflower oil appears well suited technically for use in baking and frying shortening.

Of the various industrial uses for fats and oils, drying oil products appear to offer some potential for sunflowerseed oil. The most highly unsaturated sunflower oil, such as that produced in northern latitudes, could find use in the domestic coatings industry. Because it doesn't yellow on aging, it has an advantage over many drying oils in white or pastel shades of paint. Opportunities are limited, however, because this industry has been shifting from natural fats and oils to synthetic chemicals.

Sunflower meal could be used by U.S. feed manufacturers as a high-protein ingredient in mixed feeds. To date, feeding trials with sunflower meal indicate that in ruminant rations, it is equal to other oilseed meals as a nitrogen source. In broiler and swine rations, indications are that it can replace up to 50 percent of the protein supplied by soybean meal. Further research is needed, particularly research on meal from high-oil sunflower varieties.

The absence of toxins in sunflower meal favors its use over many oilseed meals as a high-protein supplement in human foods. A major drawback is a color change--from white to beige to green to brown--that can take place in the meal. Also, as the color changes, it is accompanied by a change in the pH level--from acid to alkaline. If methods to overcome these problems are developed, use of sunflower meal in foods could find acceptance among U.S. consumers.

Sunflowerseed hulls can be used as a roughage ingredient in livestock feeds. They make a coarse roughage, high in fiber but suitable for use in ruminant rations. When finely ground to prevent separation, they can be used in mixed feeds to serve as a carrier or to add bulk to a ration. According to oilseed processors in the southern United States, sunflowerseed hulls have sold well to livestock feeders at about the same price as cottonseed hulls. Before this market can be expected to expand, however, research is needed to determine the value of sunflowerseed hulls in ruminant rations and optimum conditions under which they can be used in mixed feeds.

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by W. K. Trotter, H. O. Doty, Jr., W. D. Givan, and J. V. Lawler*

INTRODUCTION

Sunflowers rank as one of the world's leading oilseed crops. World production of sunflowerseed oil in 1971 amounted to 3.9 million tons and constituted one-sixth of total world production of edible vegetable oils (table 1). Only soybean oil and peanut oil exceeded sunflower oil in importance, with 1971 production of these oils totaling 6.8 million and 4.0 million tons, respectively. During 1962-71, sunflower oil production increased at an average annual rate of 6.2 percent, compared with 6.3 percent for soybean oil and 1.6 percent for peanut oil.

Table 1--World production of edible vegetable oils, 1971, and growth rate, 1962-71

Oil	World production, 1971		Average annual growth rate, 1962-71
	1,000 tons	Percent	Percent
Soybean	6,785	29.6	+6.3
Peanut	3,980	17.3	+1.6
Sunflowerseed	3,935	17.2	+6.2
Rapeseed	2,660	11.6	+7.9
Cottonseed	2,610	11.4	+0.4
Olive	1,595	7.0	+1.6
Sesame	790	3.4	+1.6
Corn	330	1.4	+3.5
Safflower	260	1.1	+3.7
Total	22,945	100.0	+4.1

Source: (37).

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The U.S.S.R. is the largest producer of sunflower oil. In recent years, approximately 12 million acres of sunflowers have been grown there annually. Other principal producing countries are Argentina, Bulgaria, Romania, Turkey, and South Africa.

The sunflower plant is a native of North America. It was grown by the Indians for food in North Carolina before 1600 and by the New England colonists for hair oil as early as 1615 (20). 1/ It was introduced into Spain from Central America before the middle of the 16th century.

Sunflowers have been grown in the United States on a limited scale for a number of years, principally for sale to the whole-seed market. Prior to 1967, this production was largely confined to the large seed or medium large seed varieties suitable for the birdseed, nut, and confectionery markets.

In the United States, first commercial production of sunflowers for oil occurred in 1967 with the introduction of high-oil varieties developed in the U.S.S.R. This production has been concentrated in the Red River Valley area of Minnesota and North Dakota. In 1967, 93,000 acres of oil varieties of sunflower were harvested in these two States (table 2). Harvested acreage dropped to slightly over 50,000 acres in 1968 and 1969, but increased sharply to 73,000 acres in 1970 and to 159,000 acres in 1971. Planted acreage in 1972 is estimated at 597,000 acres.

Table 2--Acreage, yield, production, price, and value, oil-type sunflowerseed, Minnesota and North Dakota, 1967-71

Crop year	Harvested acreage	Yield	Production	Price	Value
	1,000 acres	Lbs./acre	1,000 pounds	¢/lb.	1,000 dollars
1967	93	1,094	101,735	4.66	4,730
1968	53	1,108	58,710	3.88	2,279
1969	52	1,088	56,600	3.92	2,223
1970	73	945	69,000	4.13	2,850
1971	159	1,102	175,290	4.48	7,712

Source: (19).

In 1968, commercial-scale trial plantings were undertaken in the Cotton Belt States under sponsorship of the National Cottonseed Products Association. Some 40,000 acres were planted that year. The trial plantings have continued each year since 1968 but on a smaller scale.

1/ Underscored numbers in parentheses refer to references at the end of this report.

The prospect of sunflowers becoming an important commercial crop in the United States has generated considerable interest in the Red River Valley area and the southern Cotton Belt States. It has been stimulated by:

1. The need for alternative cash crops in these areas;

2. The introduction of high-oil sunflower varieties from the U.S.S.R.;

3. Growing world demand for edible oils;

4. Excess crushing capacity among screw-press cotton oil mills;

5. The rising importance of sunflower oil in world markets;

6. Growing emphasis on health benefits of polyunsaturated vegetable oils in the diet; and

7. Excellent prospects of commercial introduction of higher yielding hybrid sunflowers.

PURPOSE AND SCOPE OF STUDY

In considering whether to produce a new product, one must be concerned basically with two questions: (1) What is the market for this product or similar products; and (2) can it be produced at a price to compete in the market? All other questions are essentially subordinate to these two. We may be able to modify the product in some way to give it wider acceptance or develop means for more efficient production, but these actions are still directed at our two basic questions.

The purpose of this study is to examine the above questions with respect to oilseed sunflowers as a new commercial crop for the United States. More specifically, the objectives of the study are:

1. To describe recent trends in fat and oil markets, with emphasis on domestic edible oil uses;

2. To describe characteristics of sunflower oil and examine its present and potential uses;

3. To examine historical price relationships and trends for sunflower and other vegetable oils and relate oil prices to the value of the seed;

4. To develop estimates of the yield and price required of sunflowerseed to provide returns to the producer comparable to returns received for established crops in selected farming areas; and

5. To develop estimates of the costs and profitability of processing sunflowerseed relative to cottonseed.

AN OVERVIEW OF THE FATS AND OILS MARKET

During the past 10 years, substantial increases have occurred in domestic production, consumption, and exports of oilseeds, fats and oils, and oilseed meals. Because the oil accounts for most of the total value of sunflowerseed, the major emphasis in the following discussion is on the market for the oil component.

The Domestic Market

Domestic consumption of fats and oils in 1971 amounted to 77.8 pounds per capita. Of this, about two-thirds or 52.2 pounds was consumed as food products and a little over one-third or 25.7 pounds was used in industrial products. Consumption per capita worldwide has shown a substantial upward trend in recent years, although such consumption is still far below the per capita level in the United States.

The total domestic market for fats and oils in 1971 amounted to 16,549 million pounds (table 3). Food products accounted for 11,309 million pounds or 68.3 percent of the total, and industrial products accounted for 5,240 million pounds or 31.7 percent of the total.

Table 3--Size of U.S. fats and oils market, 1971, and growth rate, 1962-71

Fats and oils markets	Quantity used in 1971 1/	Percentage of total	Average annual growth rate, 1962-71
	Million pounds	Percent	
Food products	11,309	68.3	+2.8
Industrial products	5,240	31.7	+1.4
All fat and oil products	16,549	100.0	+2.3

1/ Actual-weight basis.

Source: (31).

The overall growth rate of U.S. fat and oil markets averaged 2.3 percent a year during 1962-71. Food product markets increased at an average annual rate of 2.8 percent, compared with 1.4 percent for the industrial fats and oils market.

Food Fats and Oils

Major components of the domestic market for food fats and oils during 1962-71 are shown in figure 1. Consumption of butter and lard decreased during the period, while use of margarine, shortening (baking and frying fats), and salad and cooking oils increased. Growth in the cooking oil market was especially rapid--7.3 percent compounded annually (table 4). This market for vegetable oils doubled during 1962-71, and if growth continues at the same rate, it will double again in the next 10 years.

Table 4--Size of U.S. market for fats and oils used in food, 1971, and growth rate, 1962-71

Food use	Market size, 1971 1/	Average annual growth rate, 1962-71
	Million pounds	Percent
Butter	1,034	- 2.9
Margarine	2,264	+ 3.2
Lard	887	- 3.8
Shortening	3,429	+ 4.4
Salad oils 2/	1,027	+ 4.5
Cooking oils 2/	2,098	+ 7.3
Potato chips 2/	431	+ 6.0
Frozen french fries 2/	133	+13.0
Other edible uses	480	+ 9.9
All food products	11,309	+ 2.8

1/ Preliminary.
2/ Data on salad and cooking oils are for 1970. Breakdown for 1971 not available. Growth rate for these products based on 1960-70 period.

Sources: (29, 31).

Production of potato chips, other snack items, and frozen french fries has contributed to the growing demand for cooking oils. Another factor has been the rapid expansion in fast-food outlets, many of which specialize in fried foods such as chicken and seafood.

Almost 2.3 billion pounds of margarine were used in 1971. This component of the fats and oils market grew an average of 3.2 percent annually during 1962-71. Shortening is also an expanding outlet for fats and oils. Consumption of shortening increased at an average annual rate of 4.4 percent during 1962-71, reaching 3.4 billion pounds in 1971.

Figure 2 shows changes that occurred during 1962-71 in domestic use of

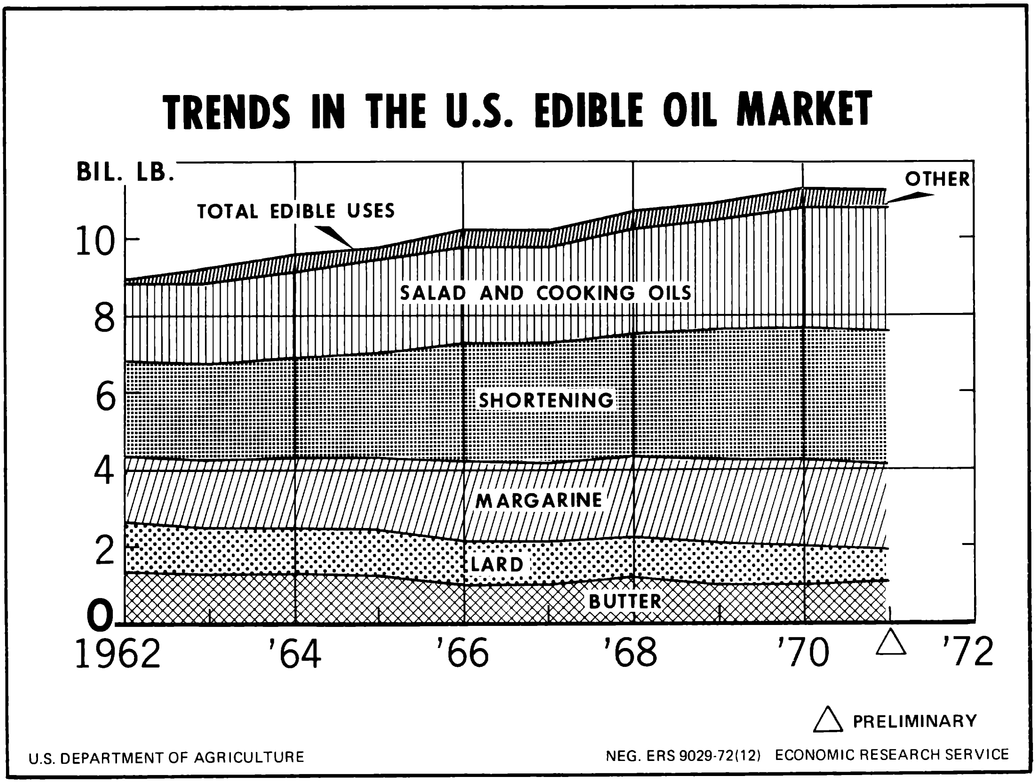

Figure 1

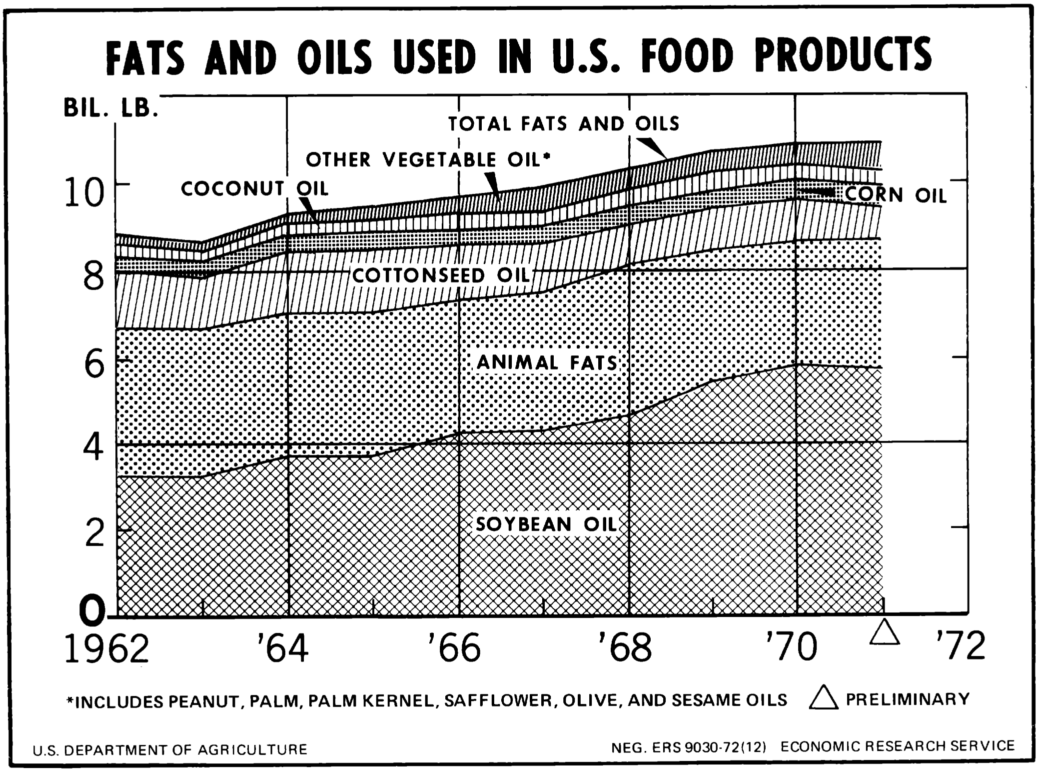

Figure 2

various food fats and oils. The growing prominence of soybean oil in our domestic food market is evident from this market profile. In 1962, soybean oil accounted for about 37 percent of fats and oils used. By 1971, its market position had increased to 53 percent. Animal fats--including butter, lard, and beef fats--accounted for 39 percent of the total in 1962 but dropped to 27 percent in 1971. Cottonseed oil also decreased in importance. The decline in animal fats was influenced by the growing emphasis on polyunsaturated oils, while the decline in cottonseed oil, a byproduct, resulted from reduced cotton acreage in recent years. Corn oil use remained relatively stable during 1962-71. Corn oil is a byproduct of the corn milling industry, and consequently its supply has not been responsive to increasing demand for premium-grade edible oils. Domestic use of coconut oil increased by 71 percent during 1962-71, from 267 million pounds in 1962 to 457 million pounds in 1971. Use of coconut oil in manufacture of snack foods and filled milk products has been a major stimulant for this growth. Other vegetable oils, principally peanut and safflower, showed a substantial increase during the period, but they still supply a rather small part of our edible oil requirements.

Industrial Fats and Oils

The domestic market for fats and oils in industrial uses totaled 5,240 million pounds in 1971--a gain of 10.9 percent over the 4,726 million pounds used in 1962. The composition of this market underwent substantial changes during the period (fig. 3). Use of fats and oils in animal feeds and fatty acid manufacture rose sharply. Use in soaps and drying oil products fell, primarily because of competition from synthetic substitutes. Increased use in feeds, fatty acids, and other industrial products more than offset the declining use in soaps and drying oil so that overall market growth averaged 1.4 percent a year during 1962-71 (table 5).

Table 5--Size of U.S. market for fats and oils used in industrial products, 1971, and growth rate, 1962-71

Product	Quantity of fats and oils used in 1971 1/	Average annual growth rate, 1962-71
	Million pounds	Percent
Soap	677	-2.2
Drying oil products	619	-4.0
Fatty acids	1,779	+4.0
Animal feeds	1,143	+4.2
Other industrial products	1,022	+1.0
All industrial products	5,240	+1.4

1/ Preliminary estimates.

Source: (29).

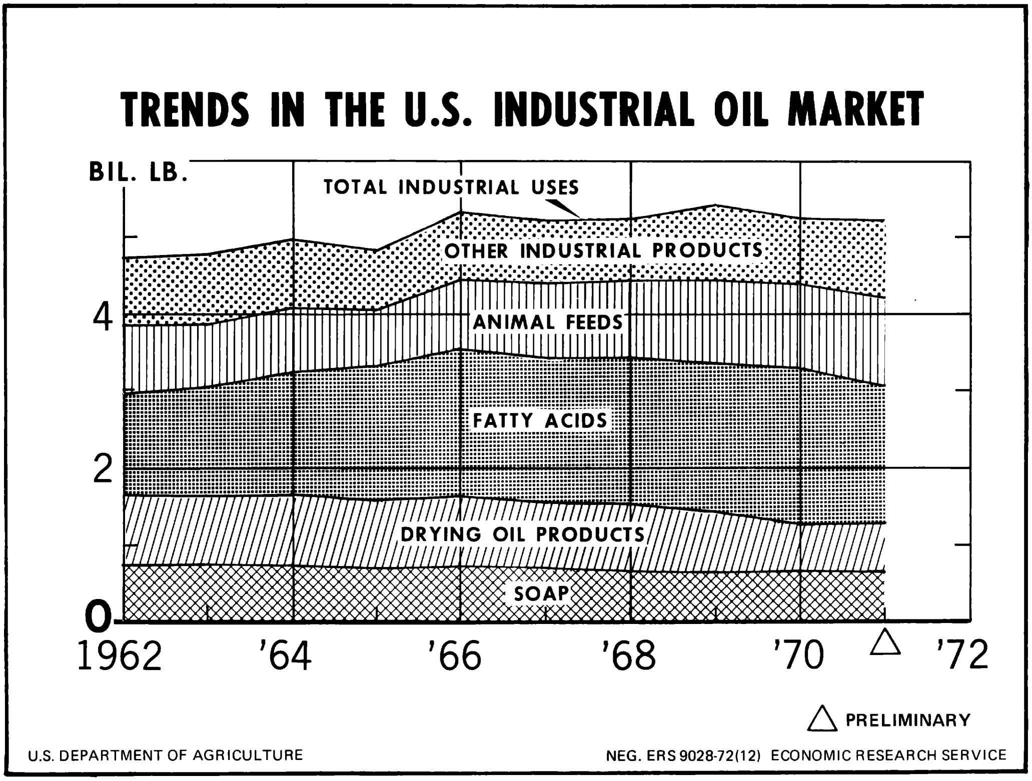

Figure 3

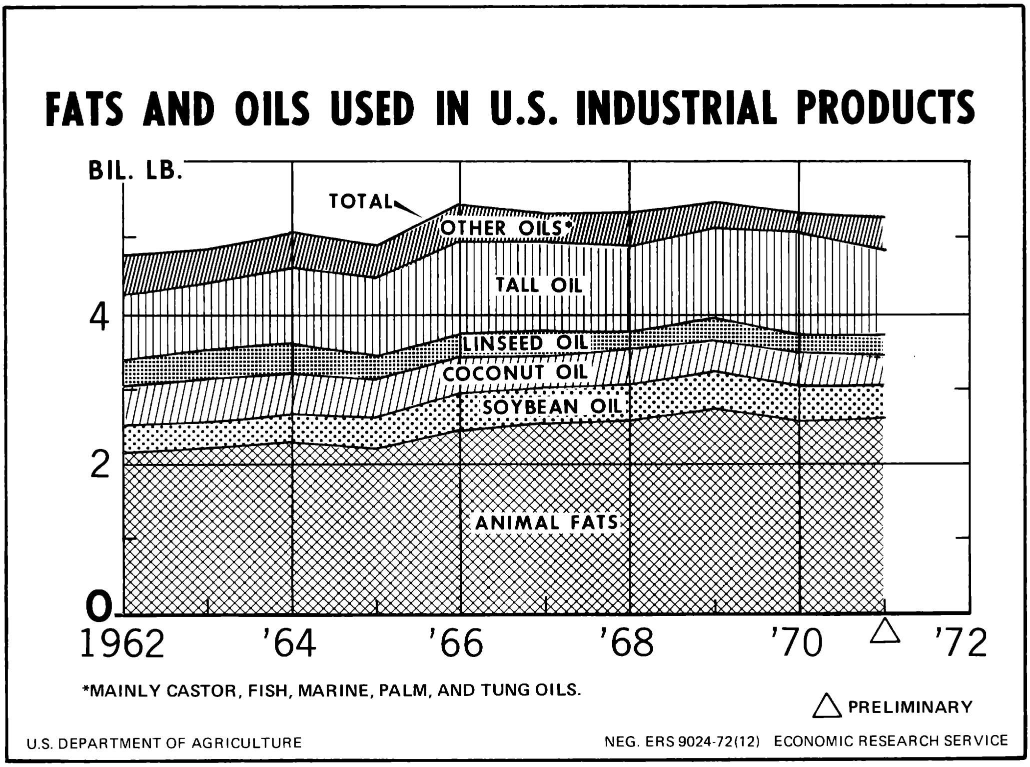

Figure 4

The changing pattern of fats and oils use in industrial products is illustrated in figure 4. Animal fats, mostly inedible tallow and grease, make up a large and increasing share of the total. Principal uses of animal fats include animal feeds, soap, and fatty acid manufacture. Tall oil is next in importance, and its use increased dramatically during 1962-71. Tall oil is the major fats and oils product used in the manufacture of fatty acids. Use of soybean oil in industrial products also increased substantially, while use of coconut oil and linseed oil decreased.

U.S. Exports of Fats and Oils

U.S. exports of fats and oils for crop years beginning October 1 increased 71 percent during 1961-70, from 6.3 billion pounds in 1961 to 10.8 billion pounds in 1970 (fig. 5). Particularly notable was the unprecedented expansion in exports of food fats and oils that occurred in 1969, when total volume reached 7.4 billion pounds. This was a 58-percent increase over the 4.7 billion pounds exported the previous year and 2.3 times the volume exported in 1961. The sharp increase resulted from reduced supplies of fats and oils available for export in several major exporting countries.

Changes in U.S. exports of food fats and oils during 1961-70 are illustrated in figure 6. The dominant position of soybean oil in our exports is evident. Soybean oil, including the oil equivalent of exported beans, has accounted for 64 to 88 percent of our edible oil exports in recent years, and its share of the export market has trended upward.

Inedible tallow and grease make up the major part of U.S. exports of industrial fats and oils (fig. 7). However, exports of linseed, marine, tall, and other oils have increased somewhat in recent years.

SUNFLOWER OIL CHARACTERISTICS

Sunflower oil is a good, high-quality oil. In the crude state, it is high yellow in color--about the same color as once-refined cottonseed oil. When refined, sunflower oil is pale yellow, has a pleasant flavor, and compares favorably with other edible vegetable oils. Its odor is distinctive, but not unpleasant, and can be removed by deodorization. Sunflower oil has a relatively low solidifying point and excellent keeping qualities. Its very low content of the highly unsaturated fatty acids, such as linolenic acid, is primarily responsible for its slow development of rancidity and hence its good stability. This gives it an advantage over many fats and oils that have stability problems. Sunflower oil's fatty-acid content makes it desirable for use as an edible oil. It has a relatively high ratio of polyunsaturated fatty acids to saturated fatty acids.

Sunflowerseed grown in the warmer climate of the south yields an oil having an iodine value of 107-115, similar to the iodine value of cottonseed oil (table 6). The iodine number represents the degree of unsaturation in the oil. According to some fats and oils users, the southern-produced oil is an ideal edible oil in terms of stability and flavor. Sunflowerseed produced in

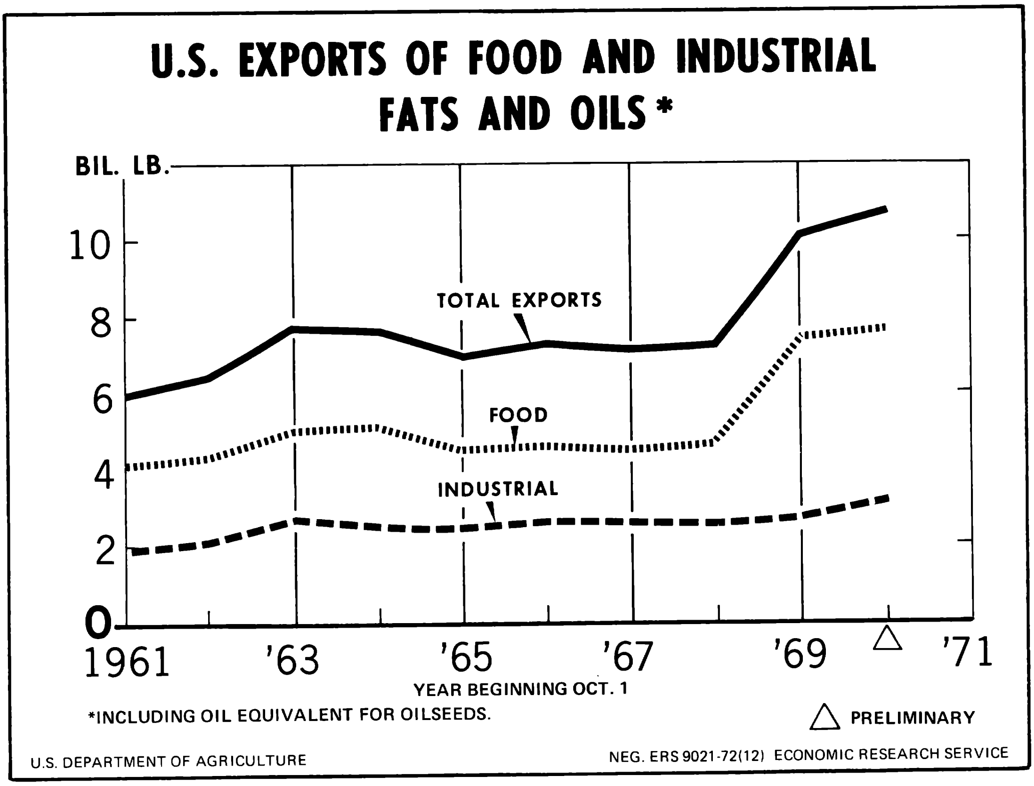

Figure 5

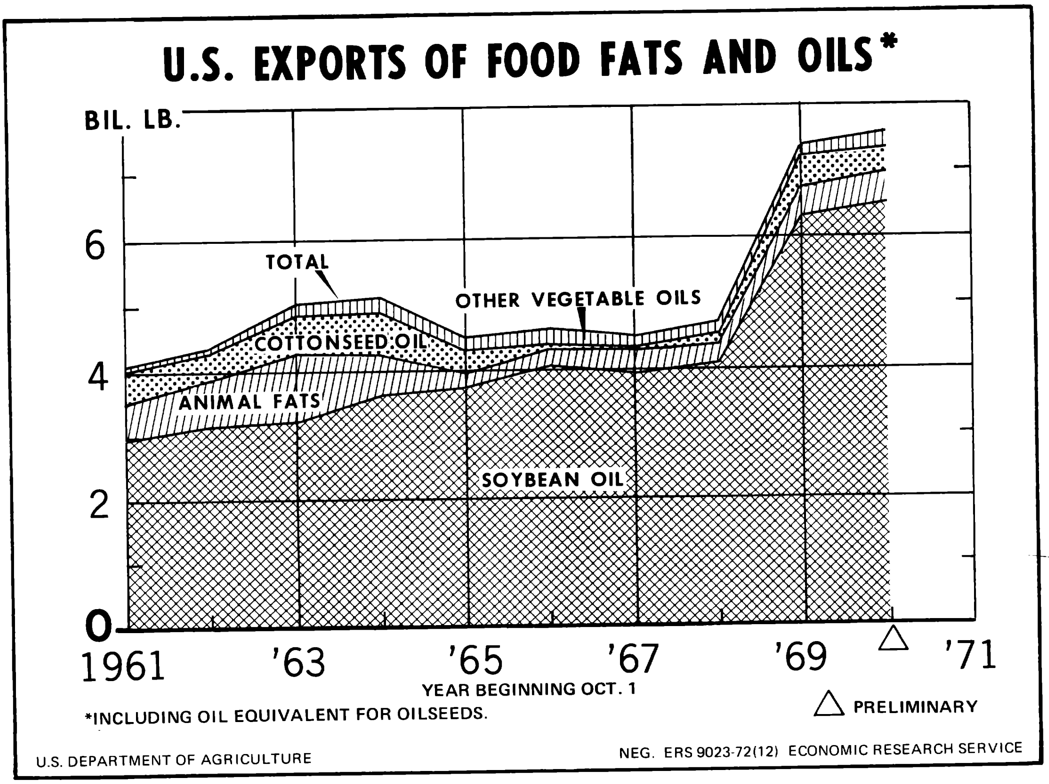

Figure 6

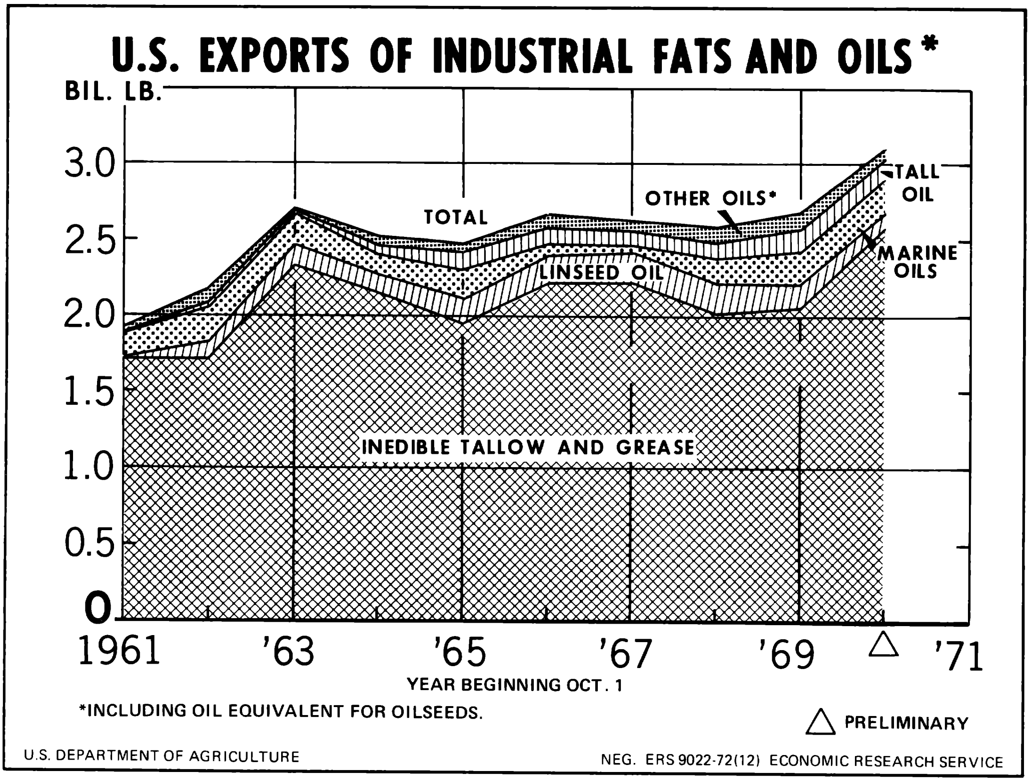

Figure 7

the colder Red River Valley area of Minnesota and North Dakota yields an oil classified as semi-drying and having an iodine value of 130-138. Compared with the southern-produced oil, the northern-produced oil is better for industrial drying oil uses. Both oils, however, can be used for edible purposes. Northern-produced sunflower oil has a higher content of linoleic acid than any other commercial edible vegetable oil except safflower oil (table 6). Linoleic acid is a polyunsaturated fatty acid having two double bonds. Some industrial drying oil users and potential users of sunflower oil, particularly those in the paint industry, believe that sunflower oil produced from northern-grown seed could find considerable use in the paint industry if its iodine value were increased.

Oleic and linoleic fatty acids make up about 90 percent of the fatty-acid content of both northern- and southern-produced sunflower oil, and these two fatty acids vary inversely with each other over a wide range (3, 13, 22, 23). There is an extremely high correlation (R = .991) between linoleic-acid content and iodine value of sunflower oil (13). The iodine number, or degree of unsaturation, in sunflower oil varies inversely with the temperature during development of the seed (8, 9, 13, 22, 23). Cooler temperatures result in increased linoleic acid and reduced oleic-acid content. It seems probable that sunflower oil with a high linoleic-acid content can only be produced in northern States, at high altitudes, or by late summer planting in southern States (13). Sunflowerseed oil from seed grown in northern States or in southern Canada typically contains about 70 percent linoleic acid (table 7). In contrast, sunflowerseed oil produced from southern-grown seed usually contains about 40 percent linoleic acid (table 8).

Table 6--Iodine value and fatty-acid content of northern- and southern-produced sunflowerseed oil and other domestic edible oils

Iodine value and fatty-acid content	Peanut oil 1/	Cottonseed oil 1/	Typical southern-produced sunflower oil 2/	Corn oil 1/	Soybean oil 1/	Typical northern-produced sunflower oil 3/	Safflower oil 1/	Linseed oil 1/
Iodine value 4/	90.1	105.0	111.3	126	132.6	138	149.1	189.1
					Percent			
Fatty-acid content:								
Myristic		1.4		0.2	0.4			
Palmitic	8.3	23.4	5.6	9.9	10.6	6.1	5/ 4.1	5/ 5.7
Stearic	6.3	1.1	3.0	2.9	2.4	5.4	5/ 1.6	5/ 3.0
C_{20} - C_{24}	7.1	1.3	0.6	0.2	2.4			
Total saturated	21.7	27.2	9.2	13.2	15.8	11.5	5.7	8.7
C_{16} and less		2.1		0.5	1.0			
Oleic	53.4	22.9	49.2	30.1	23.5	17	16.4	24.1
Linoleic	24.9	47.8	41.3	56.2	51.2	71	77.9	17.4
Linolenic					8.5	0.2		49.4
Total unsaturated	78.3	72.8	90.5	86.8	84.2	88.2	94.3	90.9

1/ Source (27).
2/ Source (13).
3/ Based on data from trade sources.
4/ The iodine number represents the degree of unsaturation in the oil.
5/ Estimates based on total saturated fatty acids.

Table 7--Composition of northern-produced sunflowerseed oil

Iodine value and fatty-acid content	Industry source #1	Industry source #2		Northern Regional Res. Laboratory 1/		Canadian Dept. of Agriculture, Morden, Manitoba 2/				
		Range	Typical	Armavirec 3/	Peredovick 3/	Peredovik 1963 3/	Peredovik 1964 3/	Armavirec 1964 3/	5 varieties, 1963	5 varieties, 1964
				Average	Average	Mean	Mean	Mean	Av. of means	Av. of means
Iodine value 4/.......	137-139	137		134.2	133.9	--	--	--	--	--
						Percent				
Fatty-acid content:										
Myristic...........	--	TRACE		TRACE		--	--	--	--	--
Palmitic...........	6.0-6.3	6-8	7	5.8	5.7	6.1	6.1	6.0	6.1	6.1
Stearic............	5.1-5.7	4-6	4.5	5.9	5.8	5.5	3.7	4.3	5.3	3.8
Total saturated.....	11-12	11-13	11.5	11.7	11.5	11.6	9.8	10.3	11.4	9.9
Oleic..............	17	15-24	16.5	18.5	17.5	16.6	16.4	18.1	17.2	17.6
Linoleic...........	70-71	62-75	72	68	69.2	71.7	73.7	71.6	71.4	72.5
Linolenic..........	0-0.3	TRACE		0.2	0.2					
Total unsaturated...		87-89	88.5	86.7	86.9	88.3	90.1	89.7	88.6	90.1

1/ Source: (4).
2/ Source: (22).
3/ Armavirec and Peredovik are the two varieties of high-oil Russian sunflower that are widest grown in this country. The averages shown are based on two observations.
4/ The iodine number represents the degree of unsaturation in the oil.

Table 8--Average composition of oil from southern-produced sunflowerseed, high-oil varieties

Item	Texas, 1961 1/	Georgia, 1967 2/	Southeastern grown, 1969 3/						
			Texas	Georgia (2 locations)	Louisiana	Alabama (3 locations)	South Carolina	North Carolina	Average
Number of varieties	6	21	7	(7 ea. location)	6	(6 ea. location)	7	4	
					Percent				
Fatty-acid content:									
Palmitic	5.6	5.5	5.7	6.4	5.6	6.0	5.4	5.3	5.7
Stearic	3.0	3.1	3.4	4.4	3.7	4.5	4.4	4.0	4.1
C_{20} - C_{24}	0.6	0.5	1.1	1.3	1.0	1.4	1.3	1.3	1.2
Total saturated	9.2	9.1	10.2	12.1	10.3	11.9	11.1	10.6	11.0
Oleic	49.2	44.6	55.7	45.6	54.0	45.7	42.7	47.9	48.6
Linoleic	41.3	45.9	33.8	42.1	33.9	41.9	46.6	41.2	39.9
Total unsaturated	90.5	90.5	89.5	87.7	87.9	87.6	89.3	89.1	88.5

1/ Source: (13).
2/ Source: (3).
3/ Source: Adapted from (23). Small amounts of palmitoleic, linolenic, arachidic, behenic, and lignoceric fatty acids were present in all samples.

Table 9--Calculated linoleic-acid percentage of oil from seed of sunflower strains grown in 1962

Entry	Name	College Station, Tex.	Lubbock, Tex.	Mesa, Ariz.	Dalton, Nebr.	Rosemount, Minn. 1/	Crookston, Minn. 1/	Davis, Calif. 2/	Manhattan, Kans.
		Percent							
Introduced varieties:									
P.I. 265099	VNIIMK 16.46	47.4	34.4	38.7	57.7	69.0	65.3	58.2	40.8
P.I. 265100	Jdanovsky 82.81	45.4	31.6			69.9	69.5	62.3	
P.I. 265101	Armavirsky 93.43	50.1	29.4	44.0	60.6	69.7	70.7	61.8	44.7
P.I. 265102	Armavirsky 93.45	41.9	28.9	47.9	65.8	69.1	64.0	62.2	45.7
P.I. 265103	VNIIMK 88.83	49.6	28.4	46.2	70.0	69.2	65.2	62.7	49.7
P.I. 265104	Tchernianka 66	53.3	29.9	58.2	70.2	69.9	62.3	65.5	50.8
Average		48.0	30.4	47.0	64.9	69.5	66.2	62.1	46.3

1/ Single determination on sample obtained by bulking seed from 4 replications at Rosemount and 3 replications at Crookston.
2/ Single determination for a seed sample from a single plot of each strain.

Source: (13, p. 419).

The effect of environmental factors, particularly temperature, on the composition of the fatty acids contained in sunflowerseed is shown in table 9. The table shows that the percentage of linoleic acid in sunflower oil produced in the northern area is much higher than for sunflower oil produced in southern locations. At the northern locations of Rosemount and Crookston, Minn., the six high-oil content Russian sunflower varieties had an average linoleic-acid content of 69.5 percent and 66.2 percent, respectively. The oil from the same varieties of sunflower grown at the southern locations of College Station and Lubbock, Tex., contained 48.0 and 30.4 percent linoleic acid, respectively. While there were differences between varieties at the various locations, linoleic-acid content of sunflower oil is influenced much more by environmental conditions than by the genotype of the variety (4, 13). However, because of the range in fatty-acid composition of sunflowerseed, breeding for specific types of oil will probably be carried out in the future (14, 22).

POTENTIAL MARKETS FOR SUNFLOWER OIL

Sunflower oil is suitable for use in a wide variety of products. It is highly regarded as a salad oil, gives excellent performance as a cooking oil, and can be used to manufacture premium-grade margarines and shortening. In addition, there is interest in using the more highly unsaturated sunflower oil in drying oil products.

A major factor affecting edible oil markets in recent years has been the concern about the cholesterol level in blood and its relation to coronary heart disease. Although the evidence of this relationship is inconclusive, a number of medical groups, such as the American Heart Association, are urging markedly reduced intake of cholesterol and saturated fats and recommending polyunsaturated vegetable oils as a substitute. The use of polyunsaturated oils tends to reduce blood cholesterol levels, and, consequently, demand for these oils has been stimulated.

Corn oil and safflower oil have been principal benefactors of this health concern because they have a lower content of saturated fatty acids and a higher content of polyunsaturated fatty acids than do either soybean oil or cottonseed oil. Since corn oil is a byproduct of the wet corn milling industry, its supply has not responded to the increased demand. Safflower oil production has expanded some in recent years but still supplies a rather small part of our total edible oil requirements. Emphasis on use of polyunsaturated oils in the diet will probably continue in the future and to meet this demand, some expansion in production of such oils will be needed. Expanded production of sunflower oil could help meet this need.

Salad and Cooking Oils

The U.S. pattern of oil use in salad and cooking oils during 1962-71 shows a sharp upward trend for soybean oil (fig. 8). In 1971, soybean oil accounted for three-fourths of total salad and cooking oils used, compared with 55 percent in 1962. Cottonseed oil is second in importance, but its use has declined in recent years, probably because of declining cotton production. Use of corn oil, peanut oil, and safflower oil in salad and cooking oils has expanded some in recent years.

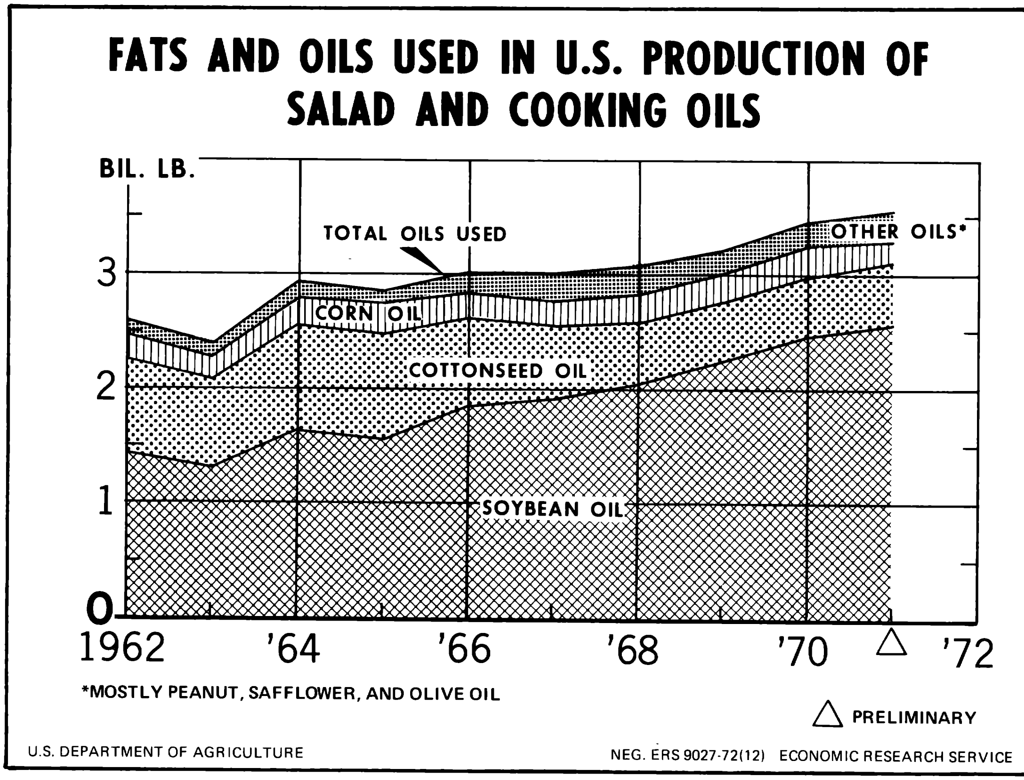

Figure 8

Anderson (2) reports that dewaxed, refined sunflower oil results in a salad oil with excellent stability and a high nutritional value. As a salad oil, it has a light yellow color and a delicate flavor. Even when off-flavor develops, sunflower oil has a mild, nut-like but still pleasant flavor. When off-flavor develops in most other domestically produced oils, the average consumer finds them varying in flavor from slightly disagreeable to highly disagreeable. Sunflower oil is much esteemed as a salad and cooking oil in Europe (10), and Japanese consumers are reported to favor sunflower oil for these purposes.

Hlavacek (9) found that the most highly unsaturated domestic sunflower oil available to date gave excellent performance as a consumer salad and cooking oil. However, he suggested that a narrower range of unsaturation would be highly desirable to simplify plant operations, including raw material monitoring and storage.

As mentioned earlier, cooking oils in recent years have been the fastest growing segment of the U.S. fats and oils market. Much of this growth may be attributed to the rising importance of snack items, such as potato chips, and the rapid emergence of fast-food outlets featuring fried chicken, seafood, and other items. In these type operations, the oil is used over several times--therefore, a highly stable oil is required. Without special processing, soybean oil may develop off-flavors after repeated use at elevated temperatures because of its unstable linolenic-acid component.

Sunflower oil makes a more desirable frying medium than does soybean oil because of its lack of linolenic acid, which, when heated, results in a catalized polymer formation. This creates a thickening and darkening of the oil, which causes a buildup on the frying or deep-fat frying vessel. Refined liquid sunflower oil offers an ideal frying oil to a large segment of the rapidly expanding snack food industry. Products fried with liquid sunflower oil will usually absorb less of the frying oil than when fried with most other domestic vegetable oils. Also, such products are reported to have a longer retail shelf life than products fried in some other oils (2).

A standard frying oil used by the potato chip industry is a 70:30 cottonseed-corn oil mixture. In potato chip frying tests comparing this mixture with sunflower oil, Evans and Shaw (5) found that in every evaluation of chips stored at room temperature, the taste panel scored those fried in sunflower oil above those fried in the cottonseed-corn oil mixture. In many comparisons, a statistically significant difference was observed in favor of the sunflower oil. The results indicated that after 4 weeks of storage at room temperature, all chips were acceptable and had satisfactory flavor.

The above results indicate that sunflower oil should have good market potential in the rapidly expanding salad and cooking oil market. It appears to be particularly well suited for use in the growing snack food industry.

Margarine

In addition to its potential use in cooking and salad oils, there is considerable interest in expanded use of sunflower oil in margarine. The sunflower's name and attractive flower, the use of the seed as an edible nut-like food, and the relatively high level of polyunsaturated fatty acids in the oil are all factors that would contribute to successful market promotion of a margarine containing sunflower oil. At least two companies have introduced sunflower margarine to the domestic market on a limited scale and reportedly it has found good acceptance.

When sunflower oil is hardened in the conventional manner for margarine production, a definite grainy texture may develop. However, various methods are available to overcome this problem, and a premium-grade margarine can be produced that has good flavor, stability, and nutritional benefits.

Soybean oil is by far the leading oil used by the domestic margarine industry (fig. 9). Soybean oil's share of this market during 1962-71 varied from a low of 72.1 percent in 1968 to a high of 78.6 percent in 1970. Use of corn oil, safflower oil, and animal fats has increased some in recent years while use of cottonseed oil has declined.

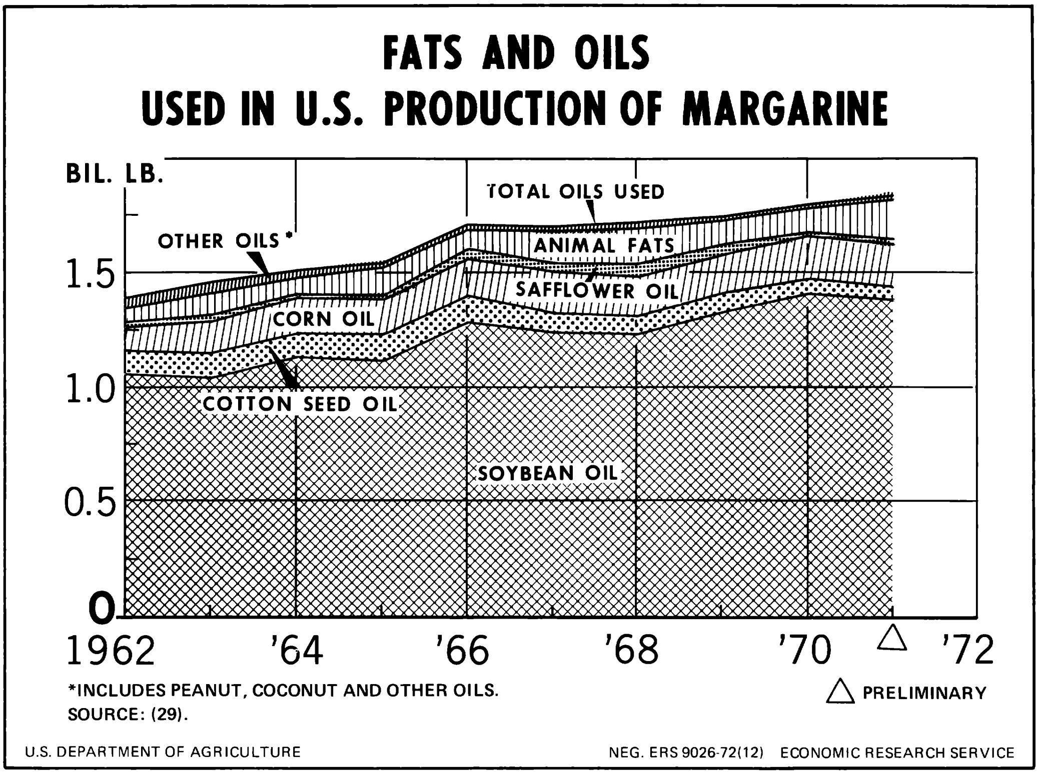

Figure 9

Sunflower oil is used extensively for the manufacture of margarine and shortening in Europe and for margarine in the U.S.S.R. (1, 9). The outlook for future U.S. use of sunflower oil in the manufacture of margarine is good, assuming dependable supplies at competitive prices. The more highly unsaturated oil could be used in margarine designed for consumers concerned with reduced intake of saturated fats and the more saturated sunflower oil could be used in regular margarine.

Shortening

Shortening prepared from sunflower oil has improved flavor stability and performs in baking at least equal to shortening produced from soybean oil (2). For frying shortening, it is superior to soybean oil with respect to polymer buildup and flavor retention. In some instances, it results in lower oil retention in the fried pieces. Thus, sunflower oil appears well suited technically for use in baking and frying shortening.

Soybean oil and animal fats accounted for most of the fats and oils used in the manufacture of shortening during 1962-71 (fig. 10). Soybean oil has accounted for most of the increase in production of shortening since 1962. Use of cottonseed oil has declined, while use of coconut and palm oil has increased. Use of animal fats in shortening also has shown some increase recently.

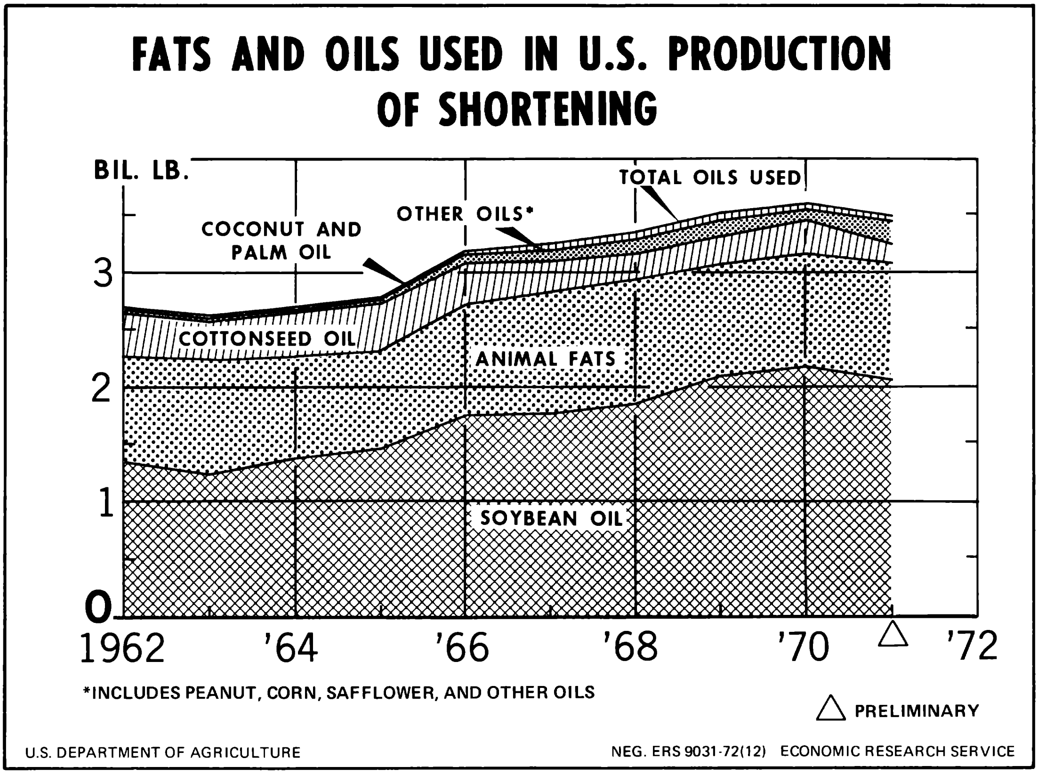

Figure 10

Substantial quantities of sunflower oil could be used domestically in the manufacture of shortening in the future, pending development of dependable supplies at competitive prices. Sunflower oil containing more saturates probably would be preferred over the more highly unsaturated oil in the manufacture of shortening.

Drying Oil Products

Of the various industrial uses for fats and oils, drying oil products appear to offer the most potential for sunflower oil and will be the only non-food market considered in this report. The more highly unsaturated sunflower oil, which is produced in northern latitudes, may find use in the surface coating market. Because of the low linolenic-acid content and good drying-oil properties of sunflower oils, the American paint industry is interested in using the oil in white and pastel shades of paint. This segment of the paint market is now held primarily by safflower oil. Natural oils with a high linolenic-acid content, such as linseed oil, cause yellowing of white and pastel shades of paint upon aging. This has been a major problem with the use of linseed oil, causing some shift away from its use in favor of other natural oils or synthetic materials.

Although some sunflower oil could be used in drying oil products, this market is not considered a major potential outlet for sunflower oil. Unless there is substantial economic incentive, it is difficult to introduce a new oil into this market because of the reluctance of manufacturers to change formulations. Also, since World War II, the protective coatings industry has been shifting to synthetic chemicals, which has resulted in a continuous downward trend in the industry's use of natural fats and oils. The market fell from 1.2 billion pounds in 1950 to 0.6 billion pounds in 1971 (29). Thus, the protective coatings industry is consuming only about one-half as much natural fats and oils as it did 20 years ago.

During the past 20 years, there has been a growing demand for paints better suited to the "do-it yourself" homeowner. Latex emulsion paints, which contain little or no drying oils, have aided the home maintenance trend because of ease of application and cleanup, quick drying, relative lack of odor, and effective industry promotions. Such properties have been incorporated into oil-based emulsion paints, but to date these paints have not enjoyed widespread use.

Total use of drying oils rose slightly during the early 1960's but has dropped sharply in recent years (fig. 11). Use of soybean oil for drying oil stayed at about the same level during this period, while use of linseed and most other natural oils declined.

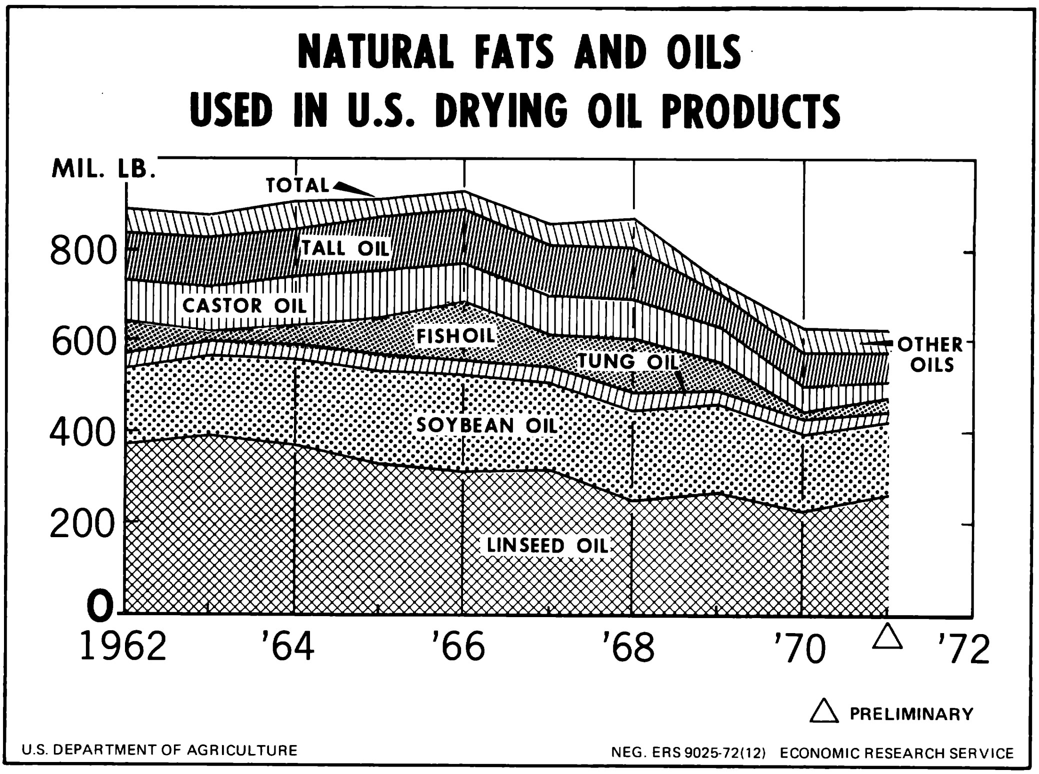

Figure 11

SUNFLOWER MEAL

Sunflower meal is the byproduct obtained when the oil is removed from sunflowerseed. Oil-extraction methods used on sunflowerseed are (1) the screw-press method, (2) the direct-solvent method, and (3) the prepress-solvent method. In the screw-press method, the hulls are removed from the seed before the oil is extracted, whereas in the direct-solvent method, the hulls are removed after extraction of the oil (tail-end screening). The third method, prepress solvent, is a combination of the first two methods. The seed is first put through a screw press and then the solvent process is used to remove the remaining oil.

Sunflower meal, like other oilseed meals, may differ in composition and nutritive value because of the method used to extract the oil, the operating procedures of the plant, the compositional condition of the seed, and the extent to which the hulls are removed.

When considering use of an oilseed meal in feed formulations, feed manufacturers and livestock feeders are interested primarily in the meal's protein content and price. Sunflower meal produced from high-oil varieties by the screw-press method has a protein content ranging from 36 to 45 percent. Solvent extraction removes more of the oil; thus, sunflower meal produced by the prepress- and direct-solvent methods will have a slightly higher protein content. Table 10 shows the composition of meal and hulls produced from high-oil sunflowers by different processing methods. Variation may occur not only in the protein content of sunflower meal, but also in the quality of the protein.

Table 10--Composition of sunflower hulls, and of sunflower meal obtained by different oil-extraction methods

Product and oil-extraction method	Percentage of--			
	Moisture	Crude protein	Fat	Fiber
	Percent			
Sunflower hulls 1/	11.5	3.5	3.4	22.1
Sunflower meal: 1/				
Screw-press method	3.5	37.6	8.7	13.9
Screw-press method	7.1	44.6	6.3	12.1
Prepress-solvent method	8.6	35.2	0.8	15.8
Direct-solvent method	8.6	47.1	1.5	3.2
Direct-solvent method	10.9	51.5	2.1	5.0

1/ These analyses were obtained from 1968 production samples. The variation between and within processes suggests the importance of feed tag analyses. Analytical values may change with additional processing experience.

Source: (18).

This variation in protein quality may result from differences in the amount of heat used in the extraction process and the care used in processing. Temperatures that are too high damage the protein, thus lowering its nutritional value.

Energy value of sunflower meal also varies, depending on the oil-extraction method and other factors. Because solvent extraction removes more oil from the meal than does the screw-press method, solvent-extracted meals have a lower energy value, unless fat is added to the meal. The screw-press method leaves between 5.5 and 10 percent oil in sunflower meal, whereas solvent-extracted meals contain .5 to 3 percent oil. Some variation in oil content and energy value also occurs in sunflower meal produced by the same type of extraction equipment.

Sunflower hulls are high in fiber. Therefore, the fiber content of sunflower meal is directly related to the amount of hull left in the meal. Monogastric animals (swine and poultry) do not utilize fiber well. Therefore, sunflower meal containing the hull is primarily limited to use in feed for ruminants (cattle and sheep). Most sunflower meal marketed has had most of the hulls removed.

Feed Use

Sunflower meal does not appear to have any unique properties that would satisfy requirements not being met by other oilseed meals. In producing complete feeds, most feed mills would blend sunflower meal with other oilseed meals and other ingredients.

The nutritive value of sunflower meal in livestock rations has been investigated in a number of feeding studies. Smith prepared a review of these studies in 1968 (26). Almost all studies up to that time were concerned with sunflower meal from low-oil varieties because 1967 was the first year in which high-oil varieties were grown commercially in the United States. These research reports were in general agreement that properly processed sunflower meal is a high-quality protein source for use in most classes of livestock and poultry rations. One plus feature of sunflower meal is that no nutritionally toxic substances have been found in it. In ruminant rations, sunflower meal is equal to other oilseed meals as a nitrogen source. In using sunflower meal in swine and poultry rations, care should be taken that adequate lysine and energy are present for maximum production because sunflower meal normally is low in lysine and may be low in energy. In some countries, sunflower meal has been used in ruminant rations for many years.

Sunflower meal from high-oil varieties has recently been tested as a high-protein feed. Waldroup and others at the University of Arkansas fed 47-percent protein, solvent-extracted sunflower meal in broiler diets (38). Results indicated that sunflower meal could replace up to 50 percent of the protein supplied by soybean meal without impairing performance of the broilers. In all-mash diets, no more than 15-20 percent solvent-extracted sunflower meal should be used. When diets were pelleted, 30 percent sunflower meal showed no difference in chick performance from control diets using soybean meal. Rose and Cole at North Dakota State University fed sunflower meal to laying hens (24). In the diets used, 50 and 100 percent of the soybean meal was replaced with sunflower meal supplemented with lysine. Results showed that sunflower meal processed from high-oil varieties can be used to replace up to 50 percent of the soybean meal protein in laying hen rations without affecting egg production or feed efficiency. When 100 percent of the soybean meal protein was replaced by sunflower meal, egg production was slightly reduced.

In swine feeding experiments, the Mississippi Agricultural and Forestry Experiment Station compared sunflower meal with soybean meal (17). Three ration treatments were used, in which sunflower meal replaced none, 50 percent, and 100 percent of the soybean meal in the rations. Results showed that sunflower meal can replace one-half of the soybean meal without seriously affecting growth rate or feed efficiency of growing pigs.

In cattle feeding experiments, the Florida Agricultural Experiment Station compared sunflower meal and cottonseed meal as supplemental protein sources in steer rations (18). The results showed little difference between these two protein sources with respect to average daily gain, feed requirements per unit gain, dressing percentage, and carcass grade.

Sunflower meal, like other oilseed meals, has some drawbacks for use in feeds. In addition to its lysine and possible energy deficiencies, the color of sunflower meal is not as desirable as some oilseed meals for use in mixed feed. Sunflower meal made from oil-type seeds is gray-black in color, while soybean meal is a golden, "rich-looking" color preferred by feed buyers.

Some researchers have reported that finely ground, solvent-extracted sunflower meal is very dusty. This probably can be remedied rather easily by adding fat to the meal in a manner similar to the way fat is added to solvent-extracted cottonseed meal to correct a dust problem. The problem also can be solved by pelleting the diets containing sunflower meal (38).

Additional research is needed on feeding sunflower meal produced from oil-type sunflower to various classes of livestock. Most research now available on sunflower meal was not conducted on oil-type sunflower meal.

The market value for sunflower meal for feed use will depend largely on the meal's nutrient content and nutrient availability in comparison with alternative protein sources. Its feeding value, like other protein sources, will vary for different classes of livestock and poultry.

In the mixed feed industry, computers are commonly used to formulate rations because of the many factors to be considered. Selection of ingredients is determined by price, the compositional coefficients assigned to the ingredients, and any restraints applied. For this reason, research is needed to more firmly establish the coefficients for sunflower meal produced from high-oil varieties by various processing methods and fed to different classes of livestock and poultry.

Sunflower meal has been well received by farmers and feed manufacturers. Processors of sunflowerseed have reported no major problems in marketing their sunflower meal. Most processors in the South have had a very limited amount of sunflower meal available for sale. This, in effect, resulted in a buyers' market with sunflower meal selling at a rather wide range in prices. Generally speaking, however, sunflower meal has sold at approximately the same price as cottonseed meal. Sunflower meal has been used primarily in dairy and beef cattle rations.

Edible Use

Use of sunflower meal as a high-protein food supplement is an interesting possibility. Research has shown that sunflower meal can be incorporated into new food formulas and also used to produce enriched traditional food products acceptable to native populations (16, 28). However, nutritionists report that for food use, sunflower meal would be more desirable if it contained more of the amino acids lysine and isoleucine.

The absence of toxins in sunflower meal is an advantage to its use in human foods. Several other important oilseed meals contain toxins that must be dealt with before the meals can be used for human consumption. Another factor favoring sunflower meal is that many consumers already are familiar with roasted sunflowerseed.

The major problem limiting use of sunflower meal in human diets at present is a color change that can take place in the meal. Upon oxidation of chlorogenic acid, a phenolic compound, the color of the meal changes from white to beige to green to brown. This darkening of color may affect the acceptability of sunflower meal in food products. There is also a change in the pH level, from acid to alkaline, as the color changes. Some research on this problem has been done at Texas A and M University and additional research in this area is needed (7, 21, 28).

SUNFLOWER HULLS

The hull accounts for 22 to 28 percent of the weight of sunflowerseed (25) and becomes a byproduct of the seed-crushing operation. Large-seed varieties have a higher proportion of hull than small-seed varieties.

The most promising use for sunflowerseed hulls appears to be as a roughage ingredient for livestock feed. Sunflower hulls make a coarse roughage, high in fiber but suitable for use in ruminant rations. When finely ground to prevent separation, they can be used in mixed feeds to serve as a carrier or to add bulk to a ration.

An example of the composition of sunflower hulls is shown in table 10. Kidd reports a different analysis for sunflower hulls removed prior to screw-press extraction (12). The oil content of these hulls was much higher than in hulls removed after solvent extraction.

According to oilseed processors in the South, sunflower hulls have sold well to livestock feeders at about the same price as cottonseed hulls.

Very little research has been done on the feeding of sunflower hulls to livestock. In 1968, the Farmers Union Grain Terminal Association conducted some sunflower hull feeding trials on lambs in South Dakota. More recently, researchers at the University of Minnesota fed pelleted sunflower hulls to lambs with good results. They fed a pound of pelleted hulls per head daily and experienced no palatability problem (11). There is need for additional research to determine the value of sunflowerseed hulls in various ruminant rations and optimum conditions under which they can be fed.

SUNFLOWER OIL PRICE

Oil is the most valuable part of the sunflowerseed. The price the processor can afford to pay for sunflowerseed, therefore, depends primarily on the price that he can expect to obtain for the oil. By the same token, the economic feasibility of producing sunflowers as an oilseed crop hinges in large measure on the market price for the oil.

International Prices

There are two significant price quotations for sunflower oil on international markets. One is for "any origin, ex-tank, Rotterdam," which is primarily Russian or eastern European oil, and the other is "Argentine, cif, European ports." A comparison of 1960-67 monthly averages of these two prices shows that over most of the period, they have practically been the same (6).

Figure 12 shows 1960-71 average annual prices of crude sunflower, soybean, and peanut oils (ground-nut oil) on European markets. There is a close relationship between the price movements of these three liquid edible oils. During 1966-68, under the pressure of sharply increasing supplies from Russia, the price of sunflower oil fell considerably on international markets--20 percent in 1967. Because of the increase in supply of edible oils, the price of other major competing oils and fats declined, but not as drastically. Therefore, during 1966-68, sunflower oil in Western Europe sold for less than soybean oil. In late 1968, the price of sunflower oil began recovering.

Except for 1966-68, the average price of sunflower oil remained between those of peanut oil and soybean oil, though generally closer to soybean oil. This midposition reflects the value judgment of edible oil buyers in Western Europe. The price of cottonseed oil occupies a somewhat similar midposition between the price of soybean and peanut oils in the American market. Unfortunately, prices for cottonseed oil on the European markets are not consistently available, so price comparisons over time between it and sunflower oil cannot be made.

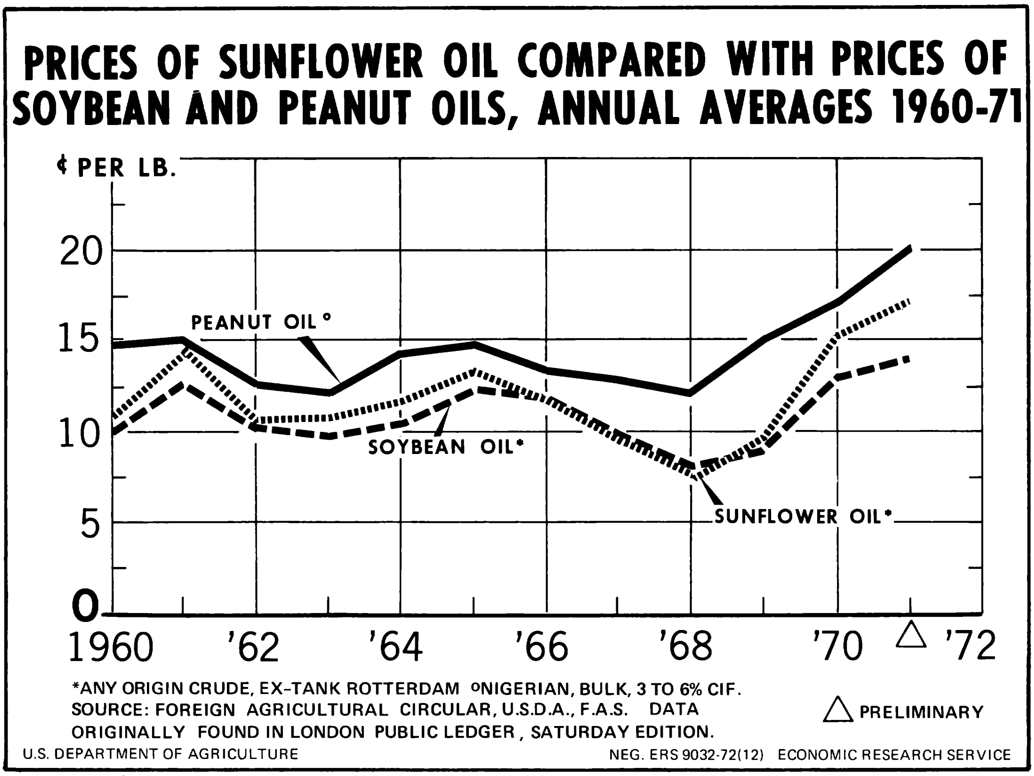

Figure 12

Recent U.S. Vegetable Oil Prices

Average domestic prices of our major edible vegetable oils, on a crude-oil basis, are shown in table 11. Average prices during 1965-69 ranged from 9.9 cents a pound for soybean oil to 15.3 cents for safflower oil. Prices in 1970-71 were substantially higher because of the reduced export availabilities in some major fats and oils exporting countries.

Comparable data are not available on the U.S. price for sunflower oil in recent years. Sunflower oil produced in the South resembles cottonseed oil in its chemical composition, but it is of higher quality in the crude state and has a lower saturated fatty-acid content. Oil produced in the Red River Valley area of the North more nearly resembles safflower oil in its fatty-acid composition. Thus, based on sunflower oil's characteristics, it would appear that the oil should sell for a price at least equivalent to the price for cottonseed oil. The more highly unsaturated sunflower oil may bring a somewhat higher price--more comparable to safflower or corn oil price. In recent years, sunflower oil sales reported by oilseed processors have usually been at about the price of cottonseed oil for small quantities and at somewhat higher prices when larger quantities are available. Higher prices have been obtained for sunflower by some firms willing to store the oil in quantity.

Table 11--Domestic wholesale prices of major vegetable oils, average 1965-69, annual 1970-71

Oil and price basis	1965-69 average	1970	1971
		Cents/pound	
Corn:			
Crude, tank cars, f.o.b. Midwest mills	14.3	16.5	19.8
Cottonseed:			
Crude, tank cars, f.o.b. Valley	12.3	13.4	15.2
Peanut:			
Crude, tank cars, f.o.b. Southeast mills	13.2	15.9	17.4
Soybean:			
Crude, tank cars, f.o.b. Decatur, Ill	9.9	12.0	12.6
Safflower:			
Tanks, New York	15.3	16.3	18.3

Source: (30, 32).

Cottonseed oil averaged 12.3 cents a pound during 1965-69, 13.4 cents in 1970, and 15.2 cents in 1971. Safflower oil averaged 15.3 cents during 1965-69, 16.3 cents in 1970, and 18.3 cents in 1971.

Table 12 relates prices and yields of sunflower oil and meal to the value of sunflowerseed. For example, with a 35-percent oil yield at 12 cents a pound for the oil and $70 a ton for the meal, sunflowerseed should be worth around $4.75 per cwt. to the processor. Yield data are based on the limited experience that southern screw-press mills had with 1968-69 trial plantings of sunflowers. Yields from the prepress-solvent mills in the Red River Valley area would, of course, differ from yields of the screw-press mills. However, the range in oil and meal yields shown in table 12 would probably cover yields from the prepress-solvent operation.

A processing margin of $20 a ton was used to arrive at these values. This is based on estimated costs of processing sunflowerseed plus an allowance for mill profits.

Table 12--Estimated value of sunflowerseed

Oil yield and price	Value of seed with price per ton of meal at-- $60	$70	$80
	Cents per pound		
30-percent oil yield:			
@10¢/lb	3.50	3.73	3.96
@12¢/lb	4.10	4.33	4.56
@14¢/lb	4.70	4.93	5.16
@16¢/lb	5.30	5.53	5.76
35-percent oil yield:			
@10¢/lb	3.85	4.05	4.26
@12¢/lb	4.55	4.75	4.96
@14¢/lb	5.25	5.45	5.66
@16¢/lb	5.95	6.15	6.36
40-percent oil yield:			
@10¢/lb	4.20	4.38	4.56
@12¢/lb	5.00	5.18	5.36
@14¢/lb	5.80	5.98	6.16
@16¢/lb	6.60	6.78	6.96

Assumes: Hull yield of 16% @$15/ton; oil + meal yield to total 76%; processing loss of 8%; processing margin, $20/ton.

Oil yields obtained by screw-press mills during the 1968 and 1969 trial plantings generally ranged between 30 and 35 percent. These yields should improve as processing techniques are improved and new hybrid sunflowers having a higher oil content are commercialized.

The values in table 12 should be referred to by readers making a close examination of data in tables 17-24 of the next section.

ECONOMICS OF PRODUCING SUNFLOWERS FOR OIL

Sunflowers can be viewed as an alternative to crops now grown in several areas of the Cotton Belt States and the Red River Valley of Minnesota and North Dakota. As such, they should yield a return at least equivalent to, and preferably in excess of, established crops in the various producing areas. Otherwise, there will be little or no commercial production of sunflowerseed for oil in the United States.

In this analysis the following questions are examined:

1. What are typical returns from established crops in the various production areas?

2. What does it cost to produce sunflowerseed?

3. What yield per acre is required to provide returns to the farmer comparable to returns from established crops?

Returns From Established Crops

Returns to land from established crops in various areas of the South are shown in table 13, and for the Red River Valley, in table 14. These returns are based on average yields of each crop in a particular area and costs estimated to be associated with these yields. Product prices used were 1971 support prices, where applicable, or average market prices received by farmers during 1968-70. Yields, production costs, and product prices used to compute returns to land for southern producing areas are given in appendix tables 1-3.

While it is realized that most farmers would achieve returns either above or below these averages, this type of analysis can indicate, in general, the level of sunflower yields that would be required to compete for farm production resources in various areas.

Sunflower Production Costs

The estimated cost of producing sunflowers is approximately $40 an acre in the Cotton Belt States and $23 an acre in the Red River Valley area of North Dakota and Minnesota (tables 15 and 16). The cost for the Cotton Belt States is representative of most areas of the southeastern and south-central States, although the composition of the cost may vary somewhat from area to area. The cost figure for the Red River Valley is based on estimates developed by the Agricultural Extension Service at North Dakota State University (20). These estimates represent the cost of inputs, other than land, required to obtain present average yields of around 1,250 pounds per acre in the Cotton Belt States and 1,000 pounds per acre in the Red River Valley area.

Should sunflowers be more widely produced, intensification of insect control would most likely be necessary, resulting in slightly higher production costs. Also, hybrid seed, which should be available in the future, will be more expensive than seed of the present open-pollinated varieties. It is estimated that these items would increase production costs above present costs by $5 to $7 an acre. Because the certainty of these additional costs is not known, and because further trial plantings may reveal ways to lower other costs, the costs of production presently being encountered are used in this analysis.

Trial plantings since 1968 have provided an increased recognition of the cultural problems involved in the production of sunflowers. Some of the

Table 13--Estimated returns to land for crops in selected areas of the southern United States

State and area	Crop						
	Cotton 1/	Cotton 2/	Corn 3/	Corn 2/	Soybeans	Grain 3/ sorghum	Grain 2/ sorghum
	Dollars						
Alabama:							
Black Prairie	72.57	7.77	20.80	8.00	36.53	--	--
Limestone Valley	123.47	37.37	35.46	20.42	40.83	--	--
Wiregrass	86.61	14.91	42.00	25.36	32.43	--	--
Georgia:							
Piedmont	70.64	3.44	28.45	15.01	34.97	--	--
Southern Coastal Plains	89.86	13.51	48.42	29.54	31.92	--	--
Southwest Coastal Plains	86.61	14.91	42.00	25.36	32.43	--	--
Mississippi:							
Delta--							
Sand soil	188.34	69.84	--	--	19.23	--	--
Clay soil	100.06	8.56	--	--	19.04	--	--
Loam soil	152.27	45.77	--	--	23.18	--	--
Brown loam--							
Mild slope	172.22	71.27	64.60	42.84	45.25	--	--
Rolling slope	138.84	51.09	39.01	23.01	28.49	--	--
South Carolina:							
Piedmont	70.64	3.44	28.45	15.01	34.97	--	--
Southern Coastal Plains	89.86	13.51	48.42	29.54	31.92	--	--
Texas:							
Central Prairie--							
Blackland	39.33	-6.87	11.98	2.38	--	24.16	11.40
Greyland	17.79	-17.91	-3.22	-12.82	--	7.14	-1.85
Low Rolling Plains--							
Clay soil	40.86	7.86	--	--	--	--	--
Loam soil	73.91	26.66	--	--	--	25.83	15.97

-- means not applicable.
1/ Includes set-aside payment of $0.15 per pound of lint for cotton produced on allotment.
2/ Excludes set-aside payment.
3/ Includes set-aside payment of $0.32 per bushel for corn and $0.29 per bushel for grain sorghum, respectively, for crop produced on one-half the feed grain base.

Table 14--Estimated average yields, prices, nonland production costs, and net returns to land for crops in the Red River Valley area of North Dakota and Minnesota, 1971

Crop	Average yield	Price-- With set-aside payment	Price-- Without set-aside payment	Nonland production cost	Net returns-- With set-aside payment	Net returns-- Without set-aside payment
	Bu./acre	---------Dol./bu.---------		Dol./acre	-------Dol./acre-------	
Duram wheat 1/	27.0	2/ 2.91	3/ 1.40	19.98	58.59	17.82
Other spring wheat 1/	25.4	2/ 2.91	3/ 1.45	19.42	54.49	17.41
Flax	9.0	none	2.80	16.28	--	8.92
Barley 1/	36.5	none	4/ .95	18.83	--	15.85
Soybeans	17.4	none	5/ 2.60	17.46	--	27.78

1/ Under conditions of continuous croping--not after fallow.
2/ With set-aside acreage under 1971 programs, wheat producers are guaranteed a minimum price of $2.91 (consisting of set-aside payment plus wheat certificate) a bushel on domestic allotment. Wheat produced in excess of that on domestic allotment is eligible for loan or can be sold at market price.
3/ Price given is expected market price. The loan price for wheat was $1.25 a bushel in 1971.
4/ Price given is expected market price. Barley produced on barley base is also eligible for loan.
5/ Price given is expected market price. The loan price for soybeans was $2.25 a bushel in 1971.

Source: (34).

Table 15--Estimated nonland costs for producing an acre of sunflowers in the southern United States

Cost per unit of input	Quantity of input needed	Cost
		Dollars
Seed at 30 cents per lb	6 lbs.	1.80
Lime at $8 per ton (prorated)	.33 ton	2.66
Mixed, applied fertilizer at $2.10 per cwt	5 cwt.	10.50
Custom applied insecticides at $2 per lb	1 lb.	2.00
Herbicides at $1.50 per lb	1 lb.	1.50
Machinery:		
Tractor at $2.55 per hour	2.1 hours	5.36
Other equipment		10.03
Subtotal		33.85
Interest on operating capital at 7 cents per dollar	$16.93	1.18
Total (excluding labor)		35.03
Operator labor at $1.50 per hour	3.3 hours	4.95
Total expenses including operator labor		39.98

Source: Developed from data furnished by sunflower producers and oil mills participating in trial plantings in the southern United States.

Table 16--Estimated nonland costs for producing an acre of sunflowers in the Red River Valley area of Minnesota and North Dakota

Cost per unit of input	Quantity of input needed	Cost
		Dollars
Seed at 30 cents per lb	5 lbs.	1.50
Fertilizer at $2.20 per cwt	1.5 cwt.	3.30
Machinery	2.25 hours	10.75
Storage and insurance at $2 per acre	1 acre	2.00
Subtotal		17.55
Interest on operating capital at 7 cents per dollar	$8.78	.61
Total (excluding labor)		18.16
Operator labor at $2 per hour	2.25 hours	4.50
Total expenses including operator labor		22.66

Source: Adapted from (20).

production problems have been solved, and there is reason to believe that others can be solved through proper management. Although the average yield of southern trial plantings has been around 1,250 pounds per acre, some producers have obtained yields of 2,000 pounds and more. This was done with no increase in production costs above those costs incurred by producers with lower yields. The higher level of management, resulting in higher sunflower yields, will be necessary if the crop is to compete with established crops. Hybrid sunflowers, with potentially higher yields and higher oil content, should permit higher returns from the crop. It appears, however, that hybrid seed on a commercial scale will not be available for several years. If the crop is to compete at the present time with other crops, it must be planted to open-pollinated varieties.

Producers in the Red River Valley area appear to have a substantial cost advantage over southern producers. Because of a cooler climate in the northern area, there is less need for extensive weed and insect control and because of less rainfall, there is a limit to the amount of fertilizer that can be used.

When considering the potential of a crop, the level of production that permits gross returns to equal estimated costs should be determined. The common sale price of sunflowerseed in 1970 was 4 cents per pound and around 4.5 cents in 1971. This is a cent to a cent and a half higher than prices received the first 2 to 3 years of trial plantings. With a sale price of 4 cents per pound, sunflower yields of 1,000 and 567 pounds per acre would be required to pay nonland costs in the southern United States and the Red River Valley, respectively. This, however, does not represent a profit.

Yields Required to Equal Returns From Established Crops

Southern United States

Historically, cotton has been the most economically significant crop in the South. Although cotton acreage has declined in recent years, cotton is still considered a major cash crop in many areas of the South. The present Government programs for cotton generally make the crop a more profitable alternative than sunflowers. However, if sunflowerseed sells for 4 cents a pound, sunflowerseed yields of 1,100 to 1,600 pounds per acre can make the crop competitive with cotton produced without payment in areas where nonpayment cotton is profitable (table 17). Exceptions would be in areas of relatively high cotton yields, such as those in the Mississippi Delta or Brown Loam area.

In recent years, soybean acreage in the southeastern States has expanded to the point where it is now considered a major cash crop. Soybean yields of 25 to 35 bushels per acre have made the crop profitable in many localities. If the price of sunflowerseed is 4 cents a pound, sunflowerseed yields of 1,600 to 2,000 pounds per acre would be needed to compete with soybeans (table 18). A price of 5 cents would bring required yields down to 1,300 to 1,600 pounds.

Table 17--Estimated sunflowerseed production required to equal returns to land from cotton, selected areas of the southern United States

State and area	Sunflowerseed production required to compete with cotton with set-aside payments 1/, when price per lb. for sunflowerseed is--			Sunflowerseed production required to compete with cotton without set-aside payments, when price per lb. for sunflowerseed is--		
	4 cents	5 cents	6 cents	4 cents	5 cents	6 cents
	Pounds per acre					
Alabama:						
Black Prairie	2,814	2,251	1,876	1,194	955	796
Limestone Valley	4,086	3,269	2,724	1,934	1,547	1,289
Wiregrass	3,165	2,532	2,110	1,372	1,098	915
Georgia:						
Piedmont	2,766	2,212	1,844	1,086	868	724
Southern Coastal Plains	3,246	2,597	2,164	1,337	1,070	892
Southwest Coastal Plains	3,165	2,523	2,110	1,372	1,098	915
Mississippi:						
Delta--						
Sand soil	5,708	4,566	3,805	2,746	2,196	1,830
Clay soil	3,515	2,812	2,343	1,214	971	809
Loam soil	4,806	3,845	3,204	2,144	1,715	1,429
Brown Loam--						
Mild slope	5,305	1,244	3,537	2,781	2,225	1,854
Rolling slope	4,471	3,576	2,980	2,277	1,821	1,518
South Carolina:						
Piedmont	2,766	2,212	1,844	1,086	868	724
Southern Coastal Plains	3,246	2,597	2,164	1,337	1,070	892
Texas:						
Central Prairie--						
Blackland	1,980	1,584	1,321	2/ 1,000	2/ 800	2/ 666
Greyland	1,444	1,155	963	2/ 1,000	2/ 800	2/ 666
Rolling Plains--						
Clay soil	2,021	1,617	1,347	1,196	957	797
Loam soil	2,847	2,278	1,898	1,666	1,333	1,111

1/ With acreage set-aside for cotton, a payment of $0.15 per pound is made for cotton produced on allotment. Cotton produced in excess of allotment or without set-aside acreage is not eligible for this payment.

2/ Break-even production for sunflowers. Net returns from cotton were negative.

Table 18--Estimated sunflowerseed production required to equal returns to land from soybeans, selected areas of the southern United States

State and area	Yield required when sunflower price per pound is--		
	4 cents	5 cents	6 cents
	Pounds per acre		
Alabama:			
Black Prairie	1,913	1,530	1,275
Limestone Valley	2,020	1,616	1,347
Wiregrass	1,810	1,448	1,207
Georgia:			
Piedmont	1,874	1,499	1,249
Southern Coastal Plains	1,798	1,438	1,198
Southwest Coastal Plains	1,810	1,448	1,207
Mississippi:			
Delta--			
Sand soil	1,480	1,184	987
Clay soil	1,476	1,180	984
Loam soil	1,579	1,263	1,053
Brown Loam--			
Mild slope	2,131	1,705	1,421
Rolling slope	1,712	1,369	1,141
South Carolina:			
Piedmont	1,874	1,499	1,249
Southern Coastal Plains	1,798	1,438	1,198

Yields of about the same magnitude would be required to compete with corn produced under the feed grain program in the southeastern States (table 19). Lower yields would compete with corn in Texas.

A substantial quantity of corn is produced in the South which is not under the feed grain program and consequently does not benefit from the support program. At 4 cents a pound for seed, sunflowerseed yields of 1,200 to 1,600 pounds would compete with such corn in most areas of the Southeast. At 5 cents, yields of 1,000 to 1,400 pounds would be competitive. In Texas, it appears that yields of around 1,000 pounds should compete with corn not under the feed grain program.

Grain sorghum is a major crop in Texas. At 4 cents a pound for the seed, sunflowerseed yields of 1,200 to 1,600 would be required to compete with sorghum produced under the feed grain program (table 20). At 5 cents a pound,

Table 19--Estimated sunflowerseed production required to equal returns to land from corn, selected areas of the southern United States

State and area	Sunflowerseed production required to compete with corn with set-aside payments 1/, when price per lb. of sunflowerseed is--			Sunflowerseed production required to compete with corn without set-aside payments, when price per lb. of sunflowerseed is--		
	4 cents	5 cents	6 cents	4 cents	5 cents	6 cents
	Pounds per acre					
Alabama:						
Black Prairie	1,520	1,216	1,013	1,200	960	800
Limestone Valley	1,886	1,509	1,257	1,510	1,208	1,007
Wiregrass	2,048	1,640	1,366	1,634	1,307	1,089
Georgia:						
Piedmont	1,711	1,369	1,141	1,375	1,100	917
Southern Coastal Plains	2,210	1,768	1,473	1,738	1,390	1,159
Southwest Coastal Plains	2,048	1,640	1,366	1,634	1,307	1,089
Mississippi:						
Brown Loam--						
Mild slope	2,615	2,092	1,743	2,071	1,656	1,380
Rolling slope	1,975	1,580	1,316	1,576	1,260	1,050
South Carolina:						
Piedmont	1,711	1,369	1,141	1,375	1,100	917
Southern Coastal Plains	2,210	1,768	1,473	1,738	1,390	1,159
Texas:						
Central Prairie--						
Blackland	1,299	1,039	866	1,059	847	706
Greyland	2/ 1,000	2/ 800	2/ 666	2/ 1,000	2/ 800	2/ 666

1/ With set-aside acreage for corn, a payment of $0.32 per bushel is made for corn produced on one-half of feed grain base.
2/ Break-even production for sunflowers. Net returns from corn were negative.

1,000 to 1,400 pounds would be competitive. Sunflower yields 200 pounds lower would compete with grain sorghum not produced under the feed grain program.

Although data for the Rolling Plains area of Texas are included in table 20, sunflowers cannot presently be produced satisfactorily in this area because of the carrot beetle. Failure to control this insect will prohibit introduction of sunflowers to this area.

Red River Valley

The established crop of major significance in this area is wheat. With yields of wheat (durum and other spring wheat) of 25 to 27 bushels per acre, sunflower yields of 1,900 to 2,000 pounds per acre would be required for the crop to compete with wheat produced on domestic allotment (table 21). Yields of 1,000 pounds would be competitive with wheat not produced under the domestic allotment. Other crops produced in this area of less economic importance are barley, flax, and soybeans. Sunflower yields required to compete with these crops are lower than those required to compete with established crops in the Cotton Belt. If the price of sunflowerseed is 4 cents a pound, yields of 900 pounds of sunflowerseed would compete with flax and a yield of around 1,100 pounds would compete with soybeans and barley.

Production Economics Summary

With sunflowerseed yields averaging around 1,250 pounds per acre and sunflowerseed prices at 3 to 4 cents a pound, sunflowers have not, in general, been competitive with established crops in the southern States during the past few years. Returns from sunflowers in the Red River Valley, where yields have averaged around 1,000 pounds, appear to be more competitive with established crops than in the southern States. Some farmers in the South have achieved yields of 2,000 pounds or more per acre, which seems to indicate that yields could be improved with better management. As experience is gained in growing the crop and higher yielding hybrid seed better adapted to the region become available, sunflowers could become a more significant factor in the U.S. farm economy.

ECONOMICS OF PROCESSING SUNFLOWERSEED

Declining acreage of cotton in the South in recent years has resulted in reduced availability of cottonseed for crushing. This has resulted in unused crushing capacity among cottonseed oil mills in the area. The excess capacity has been a major problem, especially with screw-press oil mills in the South. Screw-press mills can process sunflowerseed with only minor adjustments in equipment, whereas to process soybeans, major changes in equipment are necessary. For these reasons, emphasis in this section is placed on a comparison of the costs and returns for processing sunflowerseed and cottonseed in the South by the screw-press method.

Table 20--Estimated sunflowerseed production required to equal returns to land from grain sorghum, selected areas of the southern United States

State and area	Sunflowerseed production required to compete with grain sorghum with set-aside payments 1/, when price per lb. of sunflowerseed is--			Sunflowerseed production required to compete with grain sorghum without set-aside payments, when price per lb. of sunflowerseed is--		
	4 cents	5 cents	6 cents	4 cents	5 cents	6 cents
	Pounds per acre					
Texas:						
Central Prairie--						
Blackland	1,604	1,283	1,069	1,285	1,028	856
Greyland	1,178	942	785	2/ 1,000	2/ 800	2/ 666
Rolling Plains--						
Loam soil	1,645	1,316	1,097	1,399	1,119	933

1/ With set-aside acreage of grain sorghum, a payment of $0.29 per bushel is made for grain sorghum produced on one-half of feed grain base.
2/ Break-even production for sunflowers. Net returns from grain sorghum were negative.

Table 21--Estimated sunflowerseed production required to equal returns to land for specified crops in the Red River Valley area of North Dakota and Minnesota

Crop	Yield required when sunflower price per pound is--		
	4 cents	5 cents	6 cents
	Pounds per acre		
Durum wheat:			
Domestic allotment 1/	2,031	1,625	1,354
Other	1,012	810	675
Other spring wheat:			
Domestic allotment 1/	1,929	1,543	1,286
Other	1,002	801	668
Flax	790	632	526
Barley 2/	963	770	642
Soybeans	1,261	1,009	841

1/ With set-aside acreage, wheat produced on domestic allotment is guaranteed a minimum price of $2.91 per bushel (consisting of set-aside payment plus wheat certificates). Wheat produced in excess of that on domestic allotment is eligible for loan or can be sold at market price.
2/ Barley produced on barley base is eligible for loan. Price used for computing returns is market price.

Cost estimates were developed for two hypothetical screw-press oil mills. One estimate covers the cost of crushing cottonseed and the other, sunflowerseed. Processing costs for both oilseeds were estimated for two capacities--150 and 200 tons per day--which reflect current sizes of screw-press oil mills. Alabama-Georgia and Texas were chosen as two locations in the South where sunflower is being raised on a semicommercial basis. Representative crushing seasons of 4 and 7 months have been chosen for those areas.

Yield estimates for cottonseed were based on industry data reported to the Bureau of the Census (table 22). Yield estimates for sunflowerseed were based on data obtained from several southern mills having experience with relatively small quantities of sunflowerseed (table 23). Tables 22 and 23 show that the oil is the most important product obtained from crushing cottonseed and sunflowerseed. Cottonseed oil represents about 48 percent of the income derived from the sale of products from cottonseed crushing. The meal, while produced in larger quantity than the oil, represents about 36 percent of the income (table 22). In the case of sunflowers, oil is also the most important product, constituting about 70 to 80 percent of the income from the sale of oil, meal, and hulls (table 23).

Table 22--Estimates of cottonseed product yield and income from crushing, 1970-71

Product	Yield 1/		Price 2/	Income
	Percent	Pounds/ton	Dollars/pound	Dollars/ton
Lint	10	200	0.04	8.00
Hulls	20	400	0.017	6.80
Oil	16	320	0.14	44.80
Meal	46	920	0.037	34.04
Total	92	1,840	--	93.64

1/ Based on Bureau of Census data, 1970-71.
2/ 1970-71 average price in the southern region.

Table 23--Estimates of sunflowerseed product yield and income from crushing, 1970-71

Product	Yield 1/		Price	Income
	Percent	Pounds/ton	Dollars/pound	Dollars/ton
Oil	30	600	0.14	84.00
Meal	46	920	0.037	34.04
Hulls	16	320	0.0075	2.40
Total	92	1,840	--	120.44
Oil	35	700	0.14	98.00
Meal	41	820	0.037	30.34
Hulls	16	320	0.0075	2.40
Total	92	1,840	--	130.74
Oil	40	800	0.14	112.00
Meal	36	720	0.037	26.64
Hulls	16	320	0.0075	2.40
Total	92	1,840	--	141.04

1/ Yield estimates for screw-press method of oil extraction.

Source: Based on information furnished by industry contacts.

The detailed estimates of the costs of crushing cottonseed and sunflowerseed are shown in tables 24-26. Labor, utilities, repairs, and depreciation are important costs. Labor cost is the most important item, while depreciation is about half of the total with the longer crushing season.

Estimated gross profits for oil mills crushing cottonseed and sunflowerseed in the two southern areas are derived in tables 27-29. These data indicate that crushing sunflowerseed is profitable. The gross profit for crushing sunflowerseed ranges from about 76 percent to 190 percent of the gross profit for crushing cottonseed. The sunflower costs include payment of 4.5 cents per pound ($90 per ton) to the farmer. In fact, the higher cost of the sunflowerseed over cottonseed is the principal reason that the gross profit for sunflowerseed crushing is not higher. If oil mills paid only 4 cents per pound ($80 per ton) to farmers for sunflowerseed, then gross profits for crushing sunflowerseed would have been $10 per ton higher than the figures shown.

As might be expected, the data show that greater gross profit is realized (1) by a plant processing 200 tons of sunflowerseed a day rather than 150 tons a day, and (2) by a plant having a longer crushing season. The data also indicate that a screw-press oil mill crushing both cottonseed and sunflowerseed in the same crop year could perhaps increase its gross profit substantially compared with its former cottonseed-only operation.

The selling price of the sunflower oil is an important factor in the size of the gross profit. Depending upon the efficiency of the sunflower oil extraction operation (yield of oil), a change of 1 cent per pound in the price of the oil will increase or decrease the gross profit from $6 to $8 per ton of sunflowerseed crushed.

Table 24--Estimated cost for crushing cottonseed and sunflowerseed, 120-day crushing season, Alabama and Georgia 1/

Cost item	150-ton per day capacity		200-ton per day capacity	
	Cottonseed	Sunflowerseed	Cottonseed	Sunflowerseed
	Dollars per ton			
Variable:				
Labor	4.91	4.02	4.01	3.28
Utilities	3.90	3.20	3.61	3.05
Repairs	2.43	2.43	2.72	2.72
Mill supplies 2/	0.03	0.03	0.26	0.26
Total variable	11.54	9.95	10.60	9.31
Fixed:				
Depreciation	4.63	3.30	4.19	2.69
Insurance	0.82	0.82	0.82	0.82
Interest	0.38	0.38	0.38	0.38
Taxes	0.55	0.55	0.55	0.55
Administrative	1.49	1.49	1.34	1.34
Misc. (bookkeeping fees, etc.)	0.08	0.08	0.08	0.08
Total fixed	7.95	6.62	7.36	5.86
Total	19.49	16.57	17.96	15.17

1/ Assuming a 120-day crushing season with plant operating 24 hours per day, 7 days per week.
2/ Includes laboratory analysis, filter cloths, meal bags, etc.

Source: Based on data supplied by The French Oil Mill Machinery Company.

Table 25--Estimated cost for crushing cottonseed and sunflowerseed, 200-day crushing season, Alabama and Georgia 1/

Cost item	150-ton per day capacity		200-ton per day capacity	
	Cottonseed	Sunflowerseed	Cottonseed	Sunflowerseed
	Dollars per ton			
Variable:				
Labor	4.91	4.02	4.01	3.28
Utilities	3.90	3.20	3.61	3.05
Repair	2.43	2.43	2.72	2.72
Mill supplies 2/	0.30	0.30	0.26	0.26
Total variable	11.54	9.95	10.60	9.31
Fixed:				
Depreciation	2.78	1.98	2.51	1.62
Insurance	0.49	0.49	0.49	0.49
Interest	0.23	0.23	0.23	0.23
Taxes	0.33	0.33	0.33	0.33
Administrative	0.89	0.89	0.80	0.80
Misc. (bookkeeping fees, etc.)	0.04	0.04	0.04	0.04
Total fixed	4.76	3.96	4.40	3.51
Total	16.30	13.91	15.00	12.82

1/ Assuming a 200-day crushing season with plant operating 24 hours per day, 7 days per week. This table was derived from table 24 by assuming the variable costs per ton would not change. The fixed costs per ton were adjusted by the ratio 120/200 to account for the longer crushing season.

2/ Includes laboratory analysis, filter cloths, meal bags, etc.

Table 26--Estimated cost for crushing cottonseed and sunflowerseed, 200-day crushing season, Texas 1/

Cost item	150-ton per day capacity		200-ton per day capacity	
	Cottonseed	Sunflowerseed	Cottonseed	Sunflowerseed
	Dollars per ton			
Variable:				
Labor	4.89	4.10	4.27	3.47
Utilities	2.17	1.78	2.03	1.69
Repairs	1.47	1.47	1.63	1.63
Mill supplies 2/	0.18	0.18	0.16	0.16
Total variable	8.71	7.53	8.09	6.95
Fixed:				
Depreciation	2.90	1.98	2.62	1.61
Insurance	0.48	0.48	0.47	0.47
Interest	0.23	0.23	0.23	0.23
Taxes	0.33	0.33	0.33	0.33
Administrative	1.07	1.07	0.94	0.94
Misc. (bookkeeping fees, etc)	0.04	0.04	0.04	0.04
Total fixed	5.05	4.13	4.63	3.62
Total	13.76	11.66	12.72	10.57

1/ Assuming a 200-day crushing season, with plant operating 24 hours per day, 7 days per week.
2/ Includes laboratory analysis, filter cloths, meal bags, etc.

Source: Based on data supplied by The French Oil Mill Machinery Company.

Table 27--Estimated gross profits from crushing cottonseed and sunflowerseed, 120-day crushing season, Alabama and Georgia 1/

Cost	150-ton per day capacity				200-ton per day capacity			
	Cottonseed	Sunflowerseed			Cottonseed	Sunflowerseed		
		30% oil yield	35% oil yield	40% oil yield		30% oil yield	35% oil yield	40% oil yield
	Dollars per ton							
Gross income	93.64	120.44	130.74	141.04	93.64	120.44	130.74	141.04
Cost of seed 2/	56.00	90.00	90.00	90.00	56.00	90.00	90.00	90.00
Processing margin 3/	37.64	30.44	40.74	51.04	37.64	30.44	40.74	51.04
Processing costs	19.49	16.57	16.57	16.57	17.96	15.17	15.17	15.17
Total gross profit	18.15	13.87	24.17	34.47	19.68	15.27	25.57	35.87

1/ Assuming a 120-day crushing season, with plant operating 24 hours per day, 7 days per week.
2/ Cottonseed, estimated average price received by farmers, 1970-71; sunflowerseed, 4.5 cents per pound.
3/ Gross income less cost of seed.

Source: Tables 22-24.

Table 28--Estimated gross profits from crushing cottonseed and sunflowerseed, 200-day crushing season, Alabama and Georgia 1/

Cost	150-ton per day capacity				200-ton per day capacity			
	Cottonseed	Sunflowerseed			Cottonseed	Sunflowerseed		
		30% oil yield	35% oil yield	40% oil yield		30% oil yield	35% oil yield	40% oil yield
	Dollars per ton							
Gross income	93.64	120.44	130.74	141.04	93.64	120.44	130.74	141.04
Cost of seed 2/	56.00	90.00	90.00	90.00	56.00	90.00	90.00	90.00
Processing margin	37.64	30.44	40.74	51.04	37.64	30.44	40.74	51.04
Processing costs	16.30	13.91	13.91	13.91	15.00	12.82	12.82	12.82
Total gross profit	21.34	16.53	26.83	37.13	22.64	17.62	27.92	38.22

1/ Assuming a 200-day crushing season, with plant operating 24 hours per day, 7 days per week.
2/ Cottonseed, estimated average price received by farmers, 1970-71; sunflowerseed, 4.5 cents per pound.
3/ Gross income less cost of seed.

Source: Tables 22, 23, and 25.

Table 29--Estimated gross profits from crushing cottonseed and sunflowerseed, 200-day crushing season, Texas 1/

Cost	150-ton per day capacity				200-ton per day capacity			
	Cottonseed	Sunflowerseed			Cottonseed	Sunflowerseed		
		30% oil yield	35% oil yield	40% oil yield		30% oil yield	35% oil yield	40% oil yield
	Dollars per ton							
Gross income	93.64	120.44	130.74	141.04	93.64	120.44	130.74	141.04
Cost of seed 2/	56.00	90.00	90.00	90.00	56.00	90.00	90.00	90.00
Processing margin	37.64	30.44	40.74	51.04	37.64	30.44	40.74	51.04
Processing costs	13.76	11.66	11.66	11.66	12.72	10.57	10.57	10.57
Total gross profit	23.88	18.78	29.08	39.38	24.92	19.87	30.17	40.47

1/ Assuming a 200-day crushing season, with plant operating 24 hours per day, 7 days per week.
2/ Cottonseed, estimated average price received by farmers, 1970-71; sunflowerseed 4.5 cents per pound.
3/ Gross income less cost of seed.

Source: Tables 22, 23, and 26.

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Appendix table 1--Estimated average yields per acre for specified crops in selected areas of the southern United States

State and area	Cotton		Corn	Soybeans	Grain sorghum
	Lint	Seed			
	-----Pounds-----		-----Bushels-----		
Alabama:					
Black Prairie	432	720	40	28	--
Limestone Valley	574	956	47	31	--
Wiregrass	478	780	52	27	--
Georgia:					
Piedmont	448	731	42	26	--
Southern Coastal Plains	509	830	59	26	--
Southwest Coastal Plains	478	780	52	27	--
Mississippi:					
Delta--					
Sand soil	790	1,404	--	22	--
Clay soil	610	1,084	--	22	--
Loam soil	710	1,262	--	24	--
Brown loam--					
Mild slope	673	1,155	68	30	--
Rolling slope	585	1,000	50	23	--
South Carolina:					
Piedmont	448	731	42	26	--
Southern Coastal Plains	509	830	59	26	--
Texas:					
Central Prairie--					
Blackland	308	493	30	--	44
Greyland	238	381	20	--	31
Low Rolling Plains--					
Clay soil	220	334	--	--	--
Loam soil	315	525	--	--	34

-- means not applicable.

Source: (35).

Appendix table 2--Estimated costs per acre associated with average yields for specified crops in selected areas of the southern United States

State and area	Cotton	Corn	Soybeans	Grain Sorghum
	Dollars			
Alabama:				
Black Prairie	107.57	44.00	34.87	--
Limestone Valley	115.87	40.68	38.22	--
Wiregrass	111.36	42.24	36.42	--
Georgia:				
Piedmont	118.93	39.59	31.33	--
Southern Coastal Plains	127.82	47.16	34.38	--
Southwest Coastal Plains	111.36	42.24	36.42	--
Mississippi:				
Delta--				
Sand soil	157.41	--	36.87	--
Clay soil	166.91	--	37.06	--
Loam soil	158.47	--	38.02	--
Brown loam--				
Mild slope	121.34	45.56	31.25	--
Rolling slope	116.24	41.99	30.16	--
South Carolina:				
Piedmont	118.93	39.59	31.33	--
Southern Coastal Plains	127.82	47.16	34.38	--
Texas:				
Central Prairie--				
Blackland	75.68	36.62	--	36.12
Greyland	71.08	35.62	--	35.33
Low Rolling Plains--				
Clay soil	43.15	--	--	--
Loam soil	47.37	--	--	20.75

--means not applicable.

Source: (33, 35). Costs have been modified by adding fixed machinery costs and changing to total costs per individual acre harvested.

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Appendix table 3--Assumed prices for specified crops in selected areas of the southern United States

State and area	Cotton	Corn	Soybeans	Grain Sorghum
	Dollars			
Alabama:				
Black Prairie	.227	1.30	2.55	--
Limestone Valley	.227	1.30	2.55	--
Wiregrass	.225	1.30	2.55	--
Georgia:				
Piedmont	.234	1.30	2.55	--
Southern Coastal Plains	.239	1.30	2.55	--
Southwest Coastal Plains	.225	1.30	2.55	--
Mississippi:				
Delta--				
Sand soil	.245	1.30	2.55	--
Clay soil	.245	1.30	2.55	--
Loam soil	.245	1.30	2.55	--
Brown loam--				
Mild slope	.245	1.30	2.55	--
Rolling slope	.245	1.30	2.55	--
South Carolina:				
Piedmont	.234	1.30	2.55	--
South Coastal Plains	.239	1.30	2.55	--
Texas:				
Central Prairie--				
Blackland	.185	1.20	--	1.08
Greyland	.185	1.20	--	1.08
Low Rolling Plains--				
Clay soil	.195	--	--	--
Loam soil	.195	--	--	1.08

-- means not applicable.